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ESTIMATED PUBLIC BENEFITS
OF IMPLEMENTING
THE PROPOSED REVISIONS
TO REGULATION 308

VOLUME 111 - APPENDICES D TO I

JULY 1990



Ontario

Environment
Environnement

Jim Bradley, Minister/ministre



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ESTIMATED PUBLIC BENEFITS OF IMPLEMENTING
THE PROPOSED REVISIONS TO REGULATION 308
VOLUME III - APPENDICES D TO I

Report Prepared by:
The DPA Group Inc.
In association with:
RCG/Hagler, Bailly, Inc.
and
Monenco Consultants Ltd.

Report Prepared for:
Policy and Planning Branch
Ontario Ministry of the Environment

JULY 1990



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APPENDIX D

Emissions Data

APPENDIX D

CONTAMINANT EMISSIONS DATA SUPPLIED BY SENES CONSULTANTS

SIC CODE	PLANT TYPE (See glossary at the end of the table.)	CONTAMINANT (See glossary at the end of the table.)	EMISSIONS BY SCENARIO (tonnes/year)				
			Existing	A	B	C	D
OPEN PIT MINING							
0611	Gold Mines	PM	4,418.0	2,945.3	2,945.3	3,576.5	2,945.3
0617	Iron Ore	PM	2,857.4	1,978.2	1,978.2	2,307.9	1,978.2
TOTAL OPEN PIT MINING		PM	7,275.4	4,923.5	4,923.5	5,884.4	4,923.5
FOOD INDUSTRIES							
1011	Meat & Meat Products	Odour Units (per plant)	1E+10	9E+06	5E+06	1E+10	9E+06
	Slaughter Houses	PM	5.3	0.4	0.4	1.1	0.4
	Rendering	VOC	6.3	0.7	0.7	2.1	0.7
	Processing						0.7
1012	Poultry	Odour Units (per plant)	2E+09	9E+06	5E+06	2E+09	9E+06
	Slaughter Houses	PM	1.2	0.1	0.1	0.2	0.1
	Rendering	VOC	1.4	0.2	0.2	0.5	0.2
	Processing						0.2
1021	Fish Plants	PM	0.1	0.0	0.0	0.0	0.0
		VOC	0.1	0.0	0.0	0.0	0.0

SIC
CODE

CONTAMINANT
(See glossary
at the end of
the table.)

EMISSIONS BY SCENARIO (tonnes/year)

PLANT TYPE	SCENARIOS	EMISSIONS BY SCENARIO (tonnes/year)				
		Existing	A	B	C	D
1049 Other Dairy	PM	19.4	0.1	0.1	0.1	0.1
Whey Drying						0.1
TOTAL FOOD INDUSTRIES	PM	26.0	0.5	0.5	1.4	0.5
	VOC	7.8	0.9	0.9	2.6	0.9
						0.9

PULP & PAPER AND ALLIED PRODUCTS

PLANT TYPE	SCENARIOS	EMISSIONS BY SCENARIO (tonnes/year)				
		D	1	2	3	4
2711 Kraft Pulp Mills	PM	5,097.0	236.6	236.6	510.9	236.6
Recovery Boiler	SO2	3,226.5	1,608.5	1,608.5	3,226.5	3,226.5
	NOX	747.0	747.0	747.0	747.0	747.0
	CO	1,088.0	1,088.0	1,088.0	1,088.0	1,088.0
Lime Kiln	PM	1,538.0	577.2	577.2	766.4	577.2
	SO2	85.2	85.2	85.2	85.2	85.2
	NOX	590.0	236.6	236.6	590.0	236.6
	CO	3,638.0	3,638.0	3,638.0	3,638.0	3,638.0
Smelt Dissolving	PM	171.0	85.2	85.2	85.2	85.2
	SO2	27.0	27.0	27.0	27.0	27.0
Steam Boilers	PM	87.0	28.4	28.4	28.4	28.4
	SO2	6,391.0	473.1	6,391.0	473.1	6,391.0
	NOX	1,532.0	378.5	1,532.0	378.5	1,532.0
	CO	1,648.0	1,648.0	1,648.0	1,648.0	1,648.0

SIC
CODE

PLANT TYPE
CONTAMINANT
(See glossary
at the end of
the table.)

EMISSIONS BY SCENARIO (tonnes/year)

			A	B	C	D	E
		Existing					
	Bleach Plant	Cl2	567.0	567.0	283.9	567.0	567.0
		ClO ₂	189.0	189.0	94.6	189.0	189.0
	Total 2711 Kraft Pulp Mills	PM	6893.0	927.3	1390.9	927.3	927.3
		SO ₂	9729.7	2193.8	9729.7	2193.8	9,729.7
		NOx	2869.0	1362.0	2869.0	1362.0	2,869.0
		CO	6374.0	6374.0	6374.0	6374.0	6,374.0
		Cl2	567.0	567.0	283.9	567.0	567.0
		ClO ₂	189.0	189.0	94.6	189.0	189.0
2712	Newsprint Mills with kraft pulping	Recovery Boiler	3,377.0	55.4	55.4	343.2	55.4
		PM	2,434.0	1,217.7	1,217.7	2,434.0	1,217.7
		SO ₂	496.0	496.0	496.0	496.0	496.0
		NOx					
		CO	692.0	692.0	692.0	692.0	692.0
	Lime Kiln	PM	1,014.0	99.6	99.6	509.2	99.6
		SO ₂	103.0	55.4	55.4	55.4	55.4
		NOx	392.0	392.0	392.0	392.0	392.0
		CO	2,280.0	2,280.0	2,280.0	2,280.0	2,280.0
	Smelting Dissolving	PM	112.0	55.4	55.4	55.4	55.4
		SO ₂	34.0	33.2	33.2	33.2	34.0

SIC
CODE

PLANT TYPE
CONTAMINANT
(See glossary
at the end of
the table.)

EMISSIONS BY SCENARIO (tonnes/year)

		Existing	A	B	C	D	E
	Steam Boilers						
	PM	102.0	33.2	33.2	33.2	33.2	33.2
	SO ₂	1,594.0	553.5	553.5	1,594.0	553.5	1,594.0
	NO _x	1,223.0	442.8	442.8	1,223.0	442.8	1,223.0
	CO	1,734.0	1,734.0	1,734.0	1,734.0	1,734.0	1,734.0
	Bleach Plant						
	Cl ₂	164.0	164.0	77.5	164.0	164.0	164.0
	ClO ₂	221.0	221.0	110.7	221.0	221.0	221.0
2712	Newsprint Mills with sulphite pulping						
	Blowpit Stack	230.0	138.0	46.0	230.0	138.0	230.0
	Acid Plant	92.0	46.0	46.0	92.0	46.0	92.0
	Steam Boiler	216.0	13.8	13.8	13.8	13.8	13.8
	PM	216.0	184.0	184.0	216.0	184.0	216.0
	NO _x	562.0	562.0	562.0	562.0	562.0	562.0
	CO	330.0	230.0	230.0	322.0	230.0	230.0
	SO ₂	SO ₂	SO ₂	SO ₂	SO ₂	SO ₂	SO ₂
2712	Newsprint Mills with groundwood pulping						
	Steam Boilers	682.0	13.5	13.5	13.5	13.5	13.5
	PM	2,231.0	225.0	225.0	2,231.0	225.0	2,231.0
	SO ₂	355.0	180.0	180.0	355.0	180.0	355.0
	NO _x	1,378.0	1,378.0	1,378.0	1,378.0	1,378.0	1,378.0
	CO						

CONTAMINANT
(See glossary
at the end of
the table.)

SIC CODE PLANT TYPE

EMISSIONS BY SCENARIO (tonnes/year)

SIC CODE	PLANT TYPE		Emissions by Scenario (tonnes/year)				
			Existing	A	B	C	D
2712	Newspaper Mills						
	Steam Boilers	PM	1,120.0	35.9	35.9	35.9	35.9
		SO2	5,660.0	597.5	5,660.0	597.5	5,660.0
		NOx	1,120.0	478.0	1,120.0	478.0	1,120.0
		CO	1,650.0	1,650.0	1,650.0	1,650.0	1,650.0
Total 2712	Newspaper Mills	PM	6623.0	306.7	306.7	306.7	306.7
		SO2	12,708.0	3096.3	3004.3	12651.6	3096.3
		NOx	3802.0	2172.8	2172.8	2172.8	3,802.0
		CO	8296.0	8296.0	8296.0	8296.0	8,296.0
		Cl2	164.0	164.0	77.5	164.0	164.0
		ClO2		221.0	110.7	221.0	221.0
2713	Paperboard Mills with kraft pulping	PM	3,704.0	1,854.0	1,854.0	1,854.0	1,854.0
	Recovery Boiler	SO2	1,234.0	616.9	616.9	1,234.0	616.9
		NOx	469.0	469.0	469.0	469.0	469.0
		CO	740.0	740.0	740.0	740.0	740.0
	Lime Kiln	PM	1,110.0	109.8	109.8	555.6	109.8
		SO2	37.0	37.0	37.0	37.0	37.0
		NOx	370.0	370.0	370.0	370.0	370.0
		CO	2,470.0	2,470.0	2,470.0	2,470.0	2,470.0

SIC CODE	PLANT TYPE	CONTAMINANT (See glossary at the end of the table.)	EMISSIONS BY SCENARIO (tonnes/year)				
			Existing	A	B	C	D
		PM	62.0	32.3	32.3	32.3	32.3
		SO ₂	12.0	12.0	12.0	12.0	12.0
	Smelt Dissolving	PM	304.0	9.7	9.7	9.7	9.7
		SO ₂	91.0	91.0	91.0	91.0	91.0
		NO _X	252.0	129.2	252.0	129.2	252.0
		CO	493.0	493.0	493.0	493.0	493.0
	Steam Boilers	PM	81.0	42.0	81.0	81.0	81.0
		SO ₂	2.0	2.0	2.0	2.0	2.0
		NO _X					
		CO					
	Bleach Plant	Cl ₂					
		ClO ₂					
2713	Paperboard Mills with semi-chem pulping	PM	48.0	1.5	1.5	1.5	1.5
		SO ₂	14.0	14.0	14.0	14.0	14.0
		NO _X	44.0	20.4	44.0	20.4	44.0
		CO	11.0	11.0	11.0	11.0	11.0
2713	Paperboard Mills	PM	340.0	22.5	22.5	22.5	22.5
		SO ₂	10.0	10.0	10.0	10.0	10.0
		NO _X	107.0	107.0	107.0	107.0	107.0
		CO	30.0	30.0	30.0	30.0	30.0

SIC CODE PLANT TYPE

CONTAMINANT
(See glossary
at the end of
the table.)

EMISSIONS BY SCENARIO (tonnes/year)

			Existing	A	B	C	D	E
SIC CODE	PLANT TYPE	CONTAMINANT						
			5568.0	2029.9	2029.9	2475.6	2029.9	2029.9
		PM	1398.0	780.9	780.9	1398.0	780.9	1398.0
		SO2	1242.0	1095.6	1095.6	1242.0	1095.6	1,242.0
		NOX	3744.0	3744.0	3744.0	3744.0	3744.0	3,744.0
		CO	81.0	81.0	42.0	81.0	81.0	81.0
		Cl2	2.0	2.0	2.0	2.0	2.0	2.0
		ClO2						
2811	Business Forms	VOC	6,330.0	63.3	63.3	6,330.0	63.3	6,330.0
2819	Other Commercial Print	VOC	3,646.0	364.6	364.6	3,645.8	364.6	3,646.0
2821	Platemaking	VOC	490.0	57.6	14.6	68.8	57.6	490.0
2841	Magazines & Newspapers	VOC	38,701.0	737.2	73.7	9,337.4	737.2	38,701.0
2849	Other Printing							
	Wallpaper	VOC	0.2	0.2	0.2	0.2	0.2	0.2
	Other	VOC	3,095.0	154.8	31.0	3,095.0	154.8	3,095.0
	Total 2849 Other Printing	VOC	3,095.2	155.0	31.16	3,095.2	155.0	3,095.2

SIC
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PLANT TYPE
CONTAMINANT
(See glossary
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the table.)

EMISSIONS BY SCENARIO (tonnes/year)

		Existing	A	B	C	D	E
TOTAL PULP & PAPER AND ALLIED PRODUCTS		19,084.0	3,263.9	3,263.9	4,870.6	3,263.9	3,263.9
PM		23,835.7	6,071.0	5,979.0	23,779.3	6,071.0	23,735.7
SO ₂		7,913.0	4,630.4	4,630.4	7,913.0	4,630.4	7,913.0
NOX		18,414.0	18,414.0	18,414.0	18,414.0	18,414.0	18,414.0
CO		812.0	812.0	403.3	812.0	812.0	812.0
Cl ₂		412.0	412.0	207.3	412.0	412.0	412.0
ClO ₂		52,262.2	1,377.7	219.3	22,477.1	1,377.7	52,262.2
VOC							
IRON AND STEEL INDUSTRIES							
2911	Ferro-Alloys	PM VOC	18.9 4.1	0.3 1.6	0.3 1.6	0.3 1.6	0.3 1.6
2912	Steel Foundries	PM	8,823.3	4,170.0	4,170.0	6,759.2	4,170.0
2919	Other Primary steel						
	Electric Arc Boilers	PM PM	306.5 253.7	140.4 63.4	140.4 63.4	280.8 190.3	140.4 63.4
	TOTAL IRON AND STEEL INDUSTRIES	PM VOC	9,402.4 4.1	4,374.1 1.6	4,374.1 1.6	7,230.6 1.6	4,374.1 1.6

SIC CODE PLANT TYPE

CONTAMINANT
(See glossary
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the table.)

EMISSIONS BY SCENARIO (tonnes/year)

			Existing	A	B	C	D	E
FOUNDRIES								
2941	Iron Foundries	PM	11,406.1	1,267.3	1,267.3	2,534.7	1,267.3	1,267.3
2971	Copper/Brass Works	PM	305.8	54.9	54.9	109.8	54.9	54.9
2999	Rolled Casting	PM	92.0	13.5	13.5	24.4	13.5	13.5
	Copper	PM	186.0	2.5	2.5	55.8	2.5	2.5
	Aluminum	VOC	2.5	2.5	2.5	2.5	2.5	2.5
Total 2999	Rolled Casting	PM	278.0	16.0	16.0	80.2	16.0	16.0
	VOC	VOC	2.5	2.5	2.5	2.48	2.5	2.5
TOTAL FOUNDRIES								
		PM	11,989.9	1,338.2	1,338.2	2,724.6	1,338.2	1,338.2
		VOC	2.5	2.5	2.5	2.5	2.5	2.5
NON-FERROUS SMELTERS & REFINERIES								
2959	Primary Smelters	Arsenic	132.9	8.9	8.9	14.8	8.9	8.9
		Copper	708.9	47.3	47.3	96.0	47.3	47.3
		Iron	1,897.7	127.0	127.0	251.1	127.0	127.0
		Lead	214.1	14.0	14.0	29.5	14.0	14.0
		Nickel	494.7	34.7	34.7	66.5	34.7	34.7
		PM	15,432.3	1,026.4	1,026.4	2,060.1	1,026.4	1,026.4
		Zinc	29.5	2.2	2.2	7.4	2.2	2.2

SIC
CODE

PLANT TYPE
CONTAMINANT
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EMISSIONS BY SCENARIO (tonnes/year)

			Existing	A	B	C	D	E
		PM Lead	60.0 5.5	60.0 5.5	60.0 5.5	60.0 5.5	60.0 5.5	60.0 5.5
TOTAL NON-FERROUS SMELTERS AND REFINERIES								
	Arsenic		132.9	8.9	8.9	14.8	8.9	8.9
	Copper		708.9	47.3	47.3	96.0	47.3	47.3
	Iron		1,897.7	127.0	127.0	251.1	127.0	127.0
	Lead		219.6	19.5	19.5	35.0	19.5	19.5
	Nickel		494.7	34.7	34.7	66.5	34.7	34.7
	PM		15,492.3	1,086.4	1,086.4	2,120.1	1,086.4	1,086.4
	Zinc		29.5	2.2	2.2	7.4	2.2	2.2
AUTOMOTIVE INDUSTRY								
3231	Automotive & Parts Mfg	VOC		25,730.2	12,540.8	11,675.9	17,946.3	12,540.8
3254	Steering/Suspension	PM		41.3	41.3	4.1	41.3	41.3
3255	Brake Lining and Aluminum Wheels	Asbestos PM Talc		0.1 0.3 19.0	0.1 0.1 19.0	0.0 0.1 19.0	0.1 0.1 19.0	0.1 0.1 19.0
3259	Batteries	Lead		51.1	2.6	2.6	5.2	2.6

SIC CODE	PLANT TYPE	CONTAMINANT (See glossary at the end of the table.)	EMISSIONS BY SCENARIO (tonnes/year)			
			Existing	A	B	C
		VOC	25,730.2	12,540.8	11,675.9	17,946.3
		Lead	51.1	2.6	2.6	2.6
		Asbestos	0.1	0.1	0.0	0.1
		Talc	19.0	19.0	19.0	19.0
		PM	41.6	41.3	4.2	41.6
			D	E		

TOTAL AUTOMOTIVE INDUSTRY	VOC	25,730.2	12,540.8	11,675.9	17,946.3	12,540.8	25,730.2
	Lead	51.1	2.6	2.6	5.2	2.6	2.6
	Asbestos	0.1	0.1	0.0	0.1	0.1	0.1
	Talc	19.0	19.0	19.0	19.0	19.0	19.0
	PM	41.6	41.3	4.2	41.6	41.3	41.3

INORGANIC CHEMICAL MANUFACTURING INDUSTRIES

3511	Domestic Clay Products Manufacturing						
	Raw Materials	270.0	15.9	15.9	135.4	15.9	15.9
	PM	111.5	63.7	63.7	111.5	63.7	63.7
	PM	700.9	350.5	350.5	350.5	350.5	350.5
	VOC	111.5	63.7	63.7	111.5	111.5	111.5
	NOX	637.2	14.3	14.3	159.3	14.3	14.3
	F	10.0	9.6	9.6	9.6	9.6	9.6
	PM	876.0	446.0	446.0	446.0	446.0	446.0
	SO2						
	PM	391.5	89.2	89.2	256.4	89.2	89.2
	NOX	111.5	63.7	63.7	111.5	111.5	111.5
	F	637.2	14.3	14.3	159.3	14.3	14.3
	SO2	876.0	446.0	446.0	446.0	446.04	446.04
	Total 3511 Domestic Clay Products						

SIC
CODE

PLANT TYPE
CONTAMINANT
(See glossary
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the table.)

EMISSIONS BY SCENARIO (tonnes/year)

			Existing	A	B	C	D	E
3512	Imported Clay Products							
	Ceramics	PM (bag) HM (WWS)	58.0 1,887.0	11.6 377.4	11.6 377.4	57.9 1,886.9	11.6 377.4	11.6 377.4
Total 3512	Imported Clay Products	PM	1,945.0	389.0	389.0	1,944.8	389.0	1,945.0
3521	Cement Industry							
	Wet Kiln	PM SO2 NOx	513.0 9,324.0 10,206.0	173.3 4,725.0 10,206.0	173.3 4,725.0 10,206.0	346.5 4,725.0 10,206.0	173.3 4,725.0 10,206.0	173.3 4,725.0 10,206.0
	Dry Kiln	PM SO2 NOx	907.0 13,860.0 15,309.0	307.1 7,087.5 15,309.0	307.1 7,087.5 15,309.0	614.3 7,087.5 15,309.0	307.1 7,087.5 15,309.0	307.1 7,087.5 15,309.0
	Clinker Cool (ff)	PM PM PM PM PM	2,438.0 1,625.0 354.0 512.0 284.0	122.9 81.9 181.1 259.9 141.8	122.9 81.9 181.1 259.9 141.8	122.9 81.9 181.1 259.9 141.8	122.9 81.9 181.1 259.9 141.8	122.9 81.9 181.1 259.9 141.8
Total 3521	Cement Industry	PM SO2 NOx	6,633.0 23,184.0 25,515.0	1,267.9 11,812.5 25,515.0	1,267.9 11,812.5 25,515.0	1,748.3 11,812.5 25,515.0	1,267.9 11,812.5 25,515.0	1,267.9 11,812.5 25,515.0

SIC CODE	PLANT TYPE	CONTAMINANT (See glossary at the end of the table.)	EMISSIONS BY SCENARIO (tonnes/year)			
3571	Abrasives		Existing	A	B	C
	Aluminum Oxide	PM	541.0	138.6	138.6	138.6
	Silicon Carbide	PM	376.0	96.3	96.3	96.3
	SO2	SO2	3,667.0	185.7	185.7	185.7
Total 3571 Abrasives			917.0	234.9	234.9	234.9
		PM	3,667.0	185.7	185.7	185.7
3581	Lime		D	E		
	Lime Kiln	PM	1,660.0	829.9	1,659.7	829.9
	Product Hydration	PM	154.0	92.6	154.0	92.6
	Crushing & Grinding	PM	1,500.0	21.6	450.4	21.6
	Stockpiles	PM	10.5	5.2	5.2	5.2
	Storage	PM	9.5	4.9	4.9	4.9
Total 3581 Lime		PM	3,334.0	954.2	2,274.3	954.2

SIC	3711	General Inorganic Chemicals	Existing	A	B	C	D	E
Ammonia Products			684.0	33.5	33.5	68.0	33.5	33.5
PM		PM	845.0	27.9	27.9	51.2	27.9	27.9
SO2		SO2	136.0	48.4	48.4	82.0	48.4	48.4
NOx		NOx	3.4	0.0	0.0	3.0	0.0	0.0
F		F	1,221.0	12.1	12.1	122.0	12.1	12.1
HC		HC	272.0	27.0	27.0	54.0	27.0	27.0
NH3		NH3	87.2	0.6	0.6	4.3	0.6	0.6
PM		PM	4.7	4.7	4.7	4.7	4.7	4.7
HC		HC	1,565.0	156.5	156.5	469.5	156.5	156.5
PM		PM	236.0	22.4	22.4	89.4	22.4	22.4
SO2		SO2	111.0	55.5	55.5	88.8	55.5	55.5
NOx		NOx	1,453.0	14.5	14.5	145.3	14.5	14.5
HC		HC	0.0	0.0	0.0	0.0	0.0	0.0
NH3		NH3	145.0	14.5	14.5	145.0	14.5	14.5
PM		PM	3.3	0.3	0.3	3.3	0.3	0.3
F		F	38.0	3.8	3.8	38.0	3.8	3.8
HC		HC	844.0	84.5	84.5	84.5	84.5	84.5
PM		PM	4,846.0	49.1	49.1	4,846.0	49.1	49.1
VOC		VOC	136.0	135.7	135.7	135.7	135.7	135.7
PM		PM	1,781.0	622.5	622.5	1,066.9	622.5	622.5
NOx		NOx	7.4	0.7	0.7	7.4	0.7	0.7
HC		HC						

SIC
CODE

PLANT TYPE
CONTAMINANT
(See glossary
at the end of
the table.)

EMISSIONS BY SCENARIO (tonnes/year)

		Existing	A	B	C	D	E
Ammonium Nitrate (99.5%)	PM	751.0	79.0	79.0	750.6	79.0	79.0
	HC	113.0	26.3	26.3	113.0	26.3	26.3
	NH3	2,412.0	237.0	237.0	2,409.8	237.0	237.0
Ammonium Nitrate (63%)	Nitric Acid	328.0	39.5	39.5	328.0	39.5	39.5
	PM	712.0	76.0	76.0	709.1	76.0	76.0
	HC	266.0	25.3	25.3	265.9	25.3	25.3
	NH3	2,450.0	240.6	240.6	2,443.8	240.6	240.6
Ammonium Phosphate	Nitric Acid	350.0	38.0	38.0	350.0	38.0	38.0
	PM	85.0	1.4	1.4	1.7	1.4	1.4
	HC	1,500.0	1,500.0	1,500.0	1,500.0	1,500.0	1,500.0
	NH3	38.3	38.3	38.3	38.3	38.3	38.3
	F	22.2	0.6	0.6	2.8	0.6	0.6
Total 3711 General Inorganic Chemicals	PM	5,009.2	581.7	581.7	2,368.4	581.7	581.7
	SO2	1,081.0	50.3	50.3	140.7	50.3	50.3
	NOx	2,028.0	726.5	726.5	1,237.7	726.5	726.5
	F	28.9	0.9	0.9	9.1	0.9	0.9
	HC	4,603.1	1,587.6	1,587.6	2,196.3	1,587.6	1,587.6
	NH3	5,172.3	542.9	542.9	4,945.9	542.9	542.9
	Nitric Acid	678.0	77.5	77.5	678.0	77.5	77.5
	VOC	4846.0	49.1	49.1	4846.0	49.1	49.1
3721 Chemical Fertilizer	PM	1.6	0.1	0.1	0.7	0.1	0.1

SIC
CODE

PLANT TYPE
CONTAMINANT
(See glossary
at the end of
the table.)

EMISSIONS BY SCENARIO (tonnes/year)

		Existing	A	B	C	D	E
TOTAL INORGANIC CHEMICAL MANUFACTURING INDUSTRIES							
PM		18,231.3	3,517.0	3,517.0	8,827.9	3,517.0	5,073.0
SO2		28,808.0	12,494.5	12,494.5	12,765.9	12,494.5	12,494.5
NOX		27,654.5	26,353.0	26,305.2	26,864.2	26,353.0	26,353.0
F		666.1	15.2	15.2	168.4	15.2	15.2
HC		4,603.1	1,587.6	1,587.6	2,196.3	1,587.6	1,587.6
NH3		5,172.3	542.9	542.9	4,945.9	542.9	542.9
VOC		4,846.0	49.1	49.1	4,846.0	49.1	49.1
Nitric Acid		678.0	77.5	77.5	678.0	77.5	77.5

PETROLEUM REFINERIES

3611 Refineries

Process Combustion							
Oil	6,641.0	3,218.1	12,433.7	6,641.0	12,550.7		
oil	7,694.3	3,218.1	14,774.1	7,694.3	14,774.1		
SO2							
NOX	3,861.8	2,925.6	3,861.8	3,861.8	6,436.3		
PM	2,852.4	351.1	710.9	351.1	351.1		
VOC	93.6	29.3	29.3	46.8	29.3	93.6	
Cracker							
SO2	8,571.9	4,095.8	4,095.8	8,191.6	4,095.8	8,571.9	
NOX	1,424.8	942.0	731.4	942.0	942.0	1,424.8	
PM	1,755.3	731.4	731.4	731.4	731.4	731.4	
Sulphur Plant	5,500.1	2,750.0	2,047.9	5,500.1	2,750.0	5,500.1	
Flares, Vents	1,387.0	1,387.0	1,387.0	1,387.0	1,387.0	1,387.0	
SO2							

SIC CODE

PLANT TYPE
CONTAMINANT
(See glossary
at the end of
the table.)

EMISSIONS BY SCENARIO (tonnes/year)

			E	D	C	B	A	Existing
Tanks Storage Pumps, Compressor	VOC		1,928.0	1,462.8	1,462.8	1,928.0	1,462.8	1,928.0
	VOC		672.9	526.6	292.6	526.6	526.6	672.9
TOTAL PETROLEUM REFINERIES								
SO2		42,783.8	22,568.1	13,967.0	42,286.5	22,568.1	42,783.9	
NOX		7,861.1	4,803.8	3,657.0	4,803.8	4,803.8	7,861.0	
PM		4,607.7	1,082.5	1,082.5	1,442.3	1,082.5	1,082.5	
VOC		2,694.5	2,018.6	1,784.6	2,501.4	2,018.6	2,694.5	
ASPHALT PAVING INDUSTRY								
3699	Asphalt Paving Plants	PM	720.0	720.0	720.0	720.0	720.0	720.0
	Permanent	PM	369.0	123.0	123.0	246.0	123.0	369.0
	Portable							
TOTAL ASPHALT PAVING INDUSTRY		PM	1,089.0	843.0	843.0	966.0	843.0	1,089.0
ORGANIC CHEMICAL PRODUCTS INDUSTRY								
3712	Industrial Organic Chemicals	PVC	145.0	14.6	14.6	145.0	14.6	14.6
		PM	4,607.8	1,082.5	1,082.5	1,442.3	1,082.5	1,082.5
		NOX	326.0	32.7	32.7	326.0	32.7	32.7
		VOC						

**SIC
CODE**

PLANT TYPE
CONTAMINANT
 (See glossary
 at the end of
 the table.)

EMISSIONS BY SCENARIO (tonnes/year)

			EMISSIONS BY SCENARIO (tonnes/year)				
			Existing	A	B	C	D
	Vinyl Chloride	PM	1,442.0	148.3	148.3	1,441.4	148.3
		NOx	3,684.0	3,681.8	1,614.4	3,681.8	3,684.0
		VOC	700.0	70.0	70.0	700.0	70.0
	P.E.P.X.T.	PM	679.2	68.5	68.5	679.2	68.5
		NOx	158.0	155.7	28.7	155.7	158.0
		VOC	7,072.0	1,432.5	1,432.5	1,432.5	1,432.5
	Benzene	PM	34.0	0.0	0.0	0.2	0.0
		VOC	14.0	2.8	2.8	13.8	2.8
	Styrene	PM	12.0	0.0	0.0	0.1	0.0
		VOC	1,053.0	10.6	10.6	53.0	10.6
	S.A.B.	PM	2.0	0.0	0.0	0.1	0.0
		VOC	26.0	0.3	0.3	26.0	0.3
	Total 3712 Industrial Organic Chemicals	PM	2,314.2	231.4	231.4	2,266.0	231.4
		NOx	8,449.8	4,920.0	2,725.5	5,279.9	4,924.5
		VOC	9,191.0	1,548.8	1,548.8	2,551.3	1,548.8
	3731 Plastics & Resins	Styrene	1,307.5	0.1	0.1	0.1	0.1
	3751 Paint & Varnish Paint	PM	24.1	0.0	0.0	0.1	0.0
		VOC	1,104.0	1.2	1.2	5.6	1.2
	Varnish Paint	VOC	2,265.0	2.4	2.4	11.5	2.4

CONTAMINANT
(See glossary
at the end of
the table.)

EMISSIONS BY SCENARIO (tonnes/year)

			A	B	C	D	E
total	3751	Paint & Varnish	Existing	24.1 3369.0	0.0 3.6	0.0 17.1	0.0 3.6
			PM				0.0 3.6
			VOC				0.0 3.6
3791		Printing Ink	Existing	34.4 0.2	1.3 0.0	1.3 0.0	1.3 0.0
			PM				1.3 0.0
			VOC				
		Solvent					
		Pigment					
3792		Adhesives	Existing	0.4	0.0	0.0	0.0
			VOC				0.4
3799		Other Chemicals	Existing	52.4 190.0 9,700.0 4,012.0	5.4 182.7 498.3 659.4	5.4 121.3 498.3 1,310.9	5.4 182.7 996.7 659.4
			Pb				5.4
		Metallic					5.4
		Plasticizer &					190.0
		Solvent Reclamation					498.3
		Pigment Paint					659.4
Total	3799	Other Chemicals	Existing	4,012.0 190.0 9,700.0 52.4	659.4 182.7 498.3 5.4	1,310.9 121.3 498.3 35.0	659.4 182.7 996.7 5.4
			PM				659.4
			NOX				659.4
			VOC				190.0
			Pb				498.3
		TOTAL ORGANIC CHEMICAL PRODUCTS INDUSTRIES	PM	6,350.3 8,639.8 22,294.8 1,307.5 52.4	890.9 5,102.7 2,052.1 0.1 5.4	3,577.2 5,462.6 3,567.0 0.1 5.4	890.9 5,102.7 2,052.1 0.1 5.4
			NOX				890.9 5,114.5 2,052.5
			VOC				
			Styrene				
			Lead				

**SIC
CODE**

PLANT TYPE
 CONTAMINANT
 (See glossary
 at the end of
 the table.)

EMISSIONS BY SCENARIO (tonnes/year)

POWER GENERATION		Existing	A	B	C	D	E
4911	Electric Power Industries						
	Lakeview	PM	5,130.4	1,971.6	996.4	5,130.4	1,971.6
	Lambton	PM	6,247.1	1,664.7	841.3	6,247.1	1,664.7
	Nanticoke	PM	7,575.6	3,292.2	1,663.8	7,575.6	3,292.2
	Thunder Bay	PM	500.4	370.8	187.2	500.4	370.8
	Atikokan	PM	300.0	194.0	98.0	300.0	194.0
	Lennox	PM	443.9	443.9	443.9	443.9	443.9
	TOTAL POWER GENERATION	PM		20,197.4	7,937.2	4,230.6	20,197.4
	WASTE DISPOSAL INDUSTRIES						
4999	Transfer Station	Odour Units		50.0	0.0	0.0	0.0
	Municipal Landfill						
	1 CH4		3,298.0	67.3	67.3	101.0	67.3
	ROG		34.0	0.3	0.3	1.5	0.3
	2 CH4		1,843.0	37.6	37.6	56.4	37.6
	ROG		19.0	0.2	0.2	0.8	0.2
	3 CH4		58.0	1.2	1.2	1.8	1.2
	ROG		0.9	0.3	0.3	0.9	0.3

SIC
CODE

PLANT TYPE
CONTAMINANT
(See glossary
at the end of
the table.)

EMISSIONS BY SCENARIO (tonnes/year)

		Existing	A	B	C	D	E	
S-S Incinerator	PM	240.9	240.9	240.9	240.9	240.9	240.9	21
	SO ₂	307.0	90.4	90.4	90.4	90.4	90.4	
	NOx	188.0	105.4	105.4	180.7	105.4	90.4	
	HCl	571.0	120.5	120.5	120.5	120.5	105.4	
	Pb	2.4	2.4	2.4	2.4	2.4	2.4	
	Hg	0.2	0.2	0.2	0.2	0.2	0.2	
	Cd	1.5	1.5	1.5	1.5	1.5	1.5	
	Cr	0.6	0.6	0.6	0.6	0.6	0.6	
	PCDD	0.0012	0.0012	0.0012	0.0012	0.0012	0.0012	
	PCDF	0.00230	0.0023	0.0023	0.0023	0.0023	0.0023	
	PCB	0.2	0.2	0.2	0.2	0.2	0.2	
MC Incinerator	PM	357.7	357.7	357.7	357.7	357.7	357.7	21
	SO ₂	32.0	25.6	25.6	32.0	32.0	25.6	
	NOx	102.0	76.7	76.7	102.0	76.7	76.7	
	HCl	42.6	17.0	17.0	42.6	17.0	17.0	
	Pb	0.03	0.01	0.01	0.03	0.01	0.01	
	Hg	0.01	0.01	0.01	0.01	0.01	0.01	
	Cd	1.10	0.22	0.22	1.10	0.22	0.22	
	Cr	0.06	0.01	0.01	0.06	0.01	0.01	
	PCDD	0.0	0.0	0.0	0.0	0.0	0.0	
	PCDF	0.0	0.0	0.0	0.0	0.0	0.0	
	PCB	0.30	0.06	0.06	0.30	0.06	0.1	

SIC
CODE

PLANT TYPE
CONTAMINANT
(See glossary
at the end of
the table.)

EMISSIONS BY SCENARIO (tonnes/year)

SIC CODE	PLANT TYPE	CONTAMINANT (See glossary at the end of the table.)	EMISSIONS BY SCENARIO (tonnes/year)				
			Existing	A	B	C	D
4999	Sewage Sludge Incinerators						
	MH Incinerator	PM	152.5	29.3	29.3	29.3	29.3
		SO ₂	58.7	35.2	35.2	35.2	35.2
		NO _x	703.8	176.0	222.9	176.0	176.0
		HC	58.5	58.5	58.5	58.5	58.5
		HCl	17.6	11.7	11.7	11.7	11.7
		Pb	0.9	0.02	0.02	0.02	0.0
	FB Incinerator	PM	106.7	29.3	29.3	29.3	29.3
		SO ₂	28.4	28.4	28.4	28.4	28.4
		NO _x	152.4	105.5	105.5	105.5	105.5
		HC	58.6	58.6	58.6	58.6	58.6
		HCl	17.6	11.7	11.7	11.7	11.7
		Pb	0.10	0.02	0.02	0.02	0.0
4999	Private Waste Disposal						
	Commercial and Industrial Incinerators	PM	4.9	4.9	4.9	4.9	4.9
		SO ₂	40.6	40.6	40.6	40.6	40.6
		NO _x	121.7	73.0	73.0	73.0	73.0
		CO	178.5	178.5	178.5	178.5	178.5
		HC	24.3	24.3	24.3	24.3	24.3
		Pb	0.040	0.004	0.004	0.004	0.0
		Hg	0.2	0.2	0.2	0.2	0.2

SIC CODE	PLANT TYPE		EMISSIONS BY SCENARIO (tonnes/year)				
			Existing	A	B	C	D
4999 Institutional Waste Disposal							
	Hospitals						
	PM		108.3	0.5	0.5	1.0	0.5
	Organic Acids		71.3	0.4	0.4	0.7	0.4
	NOx		58.0	0.3	0.3	0.6	0.3
	Aldehydes		46.6	0.2	0.2	0.5	0.2
TOTAL WASTE DISPOSAL INDUSTRIES							
	PM		971.0	657.7	658.2	657.7	657.7
	SO2		466.7	220.1	226.5	220.1	220.1
	NOx		1,325.8	536.8	536.8	536.8	536.8
	HCl		648.8	161.0	186.5	161.0	161.0
	Pb		3.5	2.5	2.5	2.5	2.5
	Hg		0.4	0.4	0.4	0.4	0.4
	Cd		2.6	1.7	1.7	2.6	1.7
	Cr		0.7	0.6	0.6	0.7	0.6
	PCDD		0.0012	0.0012	0.0012	0.0012	0.0012
	PCDF		0.002	0.002	0.002	0.002	0.002
	PCB		0.5	0.2	0.2	0.5	0.2
	CH4		5,199.0	106.1	106.1	159.2	106.1
	ROG		53.9	0.8	0.8	3.2	0.8
	Organic Acids		71.3	0.4	0.4	0.7	0.4
	Aldehydes		46.6	0.2	0.2	0.5	0.2
	CO		178.5	178.5	178.5	178.5	178.5
	HC		141.6	141.6	141.6	141.6	141.6

SIC
CODE

CONTAMINANT
(See glossary
at the end of
the table.)

EMISSIONS BY SCENARIO (tonnes/year)

			Existing	A	B	C	D	E
DRY CLEANERS								
9721	Dry Cleaning Solvent Reclamation Closed System	Perchloroethylene	50.0	0.0	0.0	0.0	0.0	0.0
TOTAL DRY CLEANERS		Perchloroethylene	50.0	0.0	0.0	0.0	0.0	0.0

RESTAURANTS

		Odour Units (per restaurant)	6E+09	6E+06	6E+09	6E+06	6E+09
9211	Restaurants						

GLOSSARY

As	=	Arsenic	Hg	=	Mercury
Cd	=	Cadmium	NH ₃	=	Ammonia
CH ₄	=	Methane	Ni	=	Nickel
Cl	=	Chlorine	NO _X	=	Nitrogen Oxides
ClO ₂	=	Dioxide	Pb	=	Lead
CO	=	Carbon Monoxide	PCB	=	Polychlorinated Biphenols
Cr	=	Chromium	PCDD	=	Polychlorinated Dibenzo Dioxins
Cu	=	Copper	PCDF	=	Mixture of Chlorinated Dibenzo Dioxins and
F	=	Fluorides		=	Chlorinated Dibenzo Furans
Fe	=	Iron	PM	=	Particulate Matter
HC	=	Hydrocarbons	ROG	=	Reactive Organic Gases
HCl	=	Hydrogen Chloride	SO ₂	=	Sulphur Dioxide
			VOC	=	Volatile Organic Compounds

APPENDIX E

Speciation Profiles

TABLE OF CONTENTS

APPENDIX E

	<u>Page</u>
E.1 THE REQUIREMENT	1
E.2 APPROACH	1
E.2.1 Speciation	1
E.3 IDENTIFICATION OF SCC'S	2
E.4 SCC DATA	3
E.5 ELIMINATION OF MINOR SCC'S	4
E.6 ELIMINATION OF SUB-SECTORS NOT COVERED BY THIS STUDY	5
E.7 BOILERS	5
E.7.1 Boiler Inclusion in the Analysis	6
E.7.2 Boiler Use for Space Heat	7
E.7.3 Boiler Fuel Conversion, Sectors	7
E.7.4 Boiler Fuel Conversion, Procedure	7
E.8 CALCULATION OF SPECIATIONS	9
E.9 RESULTS	10

E - I

E.1 THE REQUIREMENT

The emissions data supplied by Senes Consultants Ltd. (see Appendix D) include two broad categories of contaminants, namely particulate matter (PM) and volatile organic compounds (VOC's). These broad categories include dozens (PM) or hundreds (VOC) of different chemicals.

Reduced emissions of particulate matter, regardless of the composition, can yield health (respiratory problems, eye irritations etc.) and other (soiling, visibility reduction) benefits. But most health and environmental benefits derived from reduced emissions of PM's and VOC's result from lower concentrations of specific chemicals. Thus, the composition of the VOC and PM emissions must be determined so that the changes in emissions of specific chemicals can be examined. This was one of the major challenges of the project.

E.2 APPROACH

Not surprisingly, the composition of the VOC's (PM's) emitted varies with the specific industrial process. The emissions from a coal-fired boiler, a gas-fired boiler and an oil-fired boiler are different. To determine the composition of VOC (PM) emissions, it is necessary to begin with the processes used in each economic sector.

E.2.1 Speciation

The only source of detailed data on the composition of VOC's and PM's is of the United States Environmental Protection Agency's (EPA), National Emissions Data System (NEDS).

As in Canada, U.S. industries are classified by Standard Industrial Classification (SIC) codes. Unfortunately, U.S. SIC codes differ from Canadian SIC codes.

In the NEDS database each U.S. SIC is divided into processes which are regarded as sources of emissions and are assigned a unique Source Classification Code (SCC). To use the SCC information on PM and VOC composition we needed to:

- . select the SCC's that correspond to each of the Canadian industries or industry segments covered by this study;
- . ensure that the SCC's selected correspond to the processes and emissions estimated by Senes; and
- . aggregate the SCC profiles of PM's and VOC's into profiles corresponding to the Canadian SIC codes covered by this study.

These steps are described below.

E.3 IDENTIFICATION OF SCC'S

The first task is to identify the unique Source Classification Codes (SCC's) needed for our analysis. The Canadian SIC codes for the industries or industry segments covered by the study are known. Statistics Canada provides a conversion table that relates each Canadian SIC code to the corresponding U.S. SIC codes. We used this conversion table to identify the relevant U.S. SIC codes. The number of U.S. SIC codes identified was approximately 50 per cent larger than the corresponding number of Canadian SIC codes.

We then obtained from the National Emissions Data System (NEDS) data for the SCC's corresponding to the identified U.S. SIC codes. We received data on approximately 15,000 SCC's.

E.4 SCC DATA

The data obtained for each SCC included:

- the U.S. SIC code that uses the process;
- the type of process;
- a description of the process including notes such as the fuel used;
- the corresponding speciation profile number which identifies the specific chemicals that comprise the VOC (PM) emissions for that process; and
- the total VOC (PM) emissions from the given process by all plants in the United States in 1985.

In theory each SCC has a unique chemical breakdown for its VOC emissions and its PM emissions. In practice, generalized profiles are common to many SCC's. For example, the composition of the VOC and PM emissions from oil-fired boilers might be similar for many industries (SIC's) that use such boilers.

It is also important to understand that the SCC's corresponding to a given SIC code do not represent a single set of processes found in all plants in that industry. Sticking with the boiler example, a given SIC code may have SCC's that correspond to oil-fired, coal-fired, and gas-fired boilers. A given plant might use only a single fuel for its boiler, so only one of the SCC's would be relevant for its emissions.

E.5 ELIMINATION OF MINOR SCC'S

As mentioned above, a large number (more than 15,000) processes (SCC's) are sources of emissions in the industrial sectors we considered. We had to find some way of cutting down this number to make the calibration of SCC's with the industry sectors covered by the study and the emissions data provided by Senes a manageable task.

We used the following procedure. We eliminated all SCC's whose contribution to total PM or total VOC emissions in the (U.S.) SIC in question was less than 5 percent.¹ In most cases, we were left with a small group of SCC's which contributed 75 percent or more of total PM or VOC emissions of U.S. firms in that industry.

In a few instances we were left with less than 75 percent of total PM or VOC emissions using the "less than 5 percent" rule. In those cases we conducted an ordered search for "minor" SCC's and put them back in the SCC grouping for the American SIC in question. We kept adding "minor" SCC's until we had 75 percent of total PM and total VOC emissions accounted for. Our ordered search involved looking for the most important SCC's of less than 5 percent, i.e., 4-5 percent, the 3-4 percent, etc.

The process of eliminating minor SCC's reduced the number from over 15,000 to less than 1,000.

¹ Only if the SCC contributed less than 5 percent of both total VOC and PM emissions was it excluded. If the SCC contributed 5.1 percent of total VOC emissions and 1.0 percent of total PM emissions it was retained.

E.6 ELIMINATION OF SUB-SECTORS NOT COVERED BY THIS STUDY

The American SIC codes include sub-sectors that are not found in Ontario or were excluded from this study. For example, the American SIC code for fish processing includes canneries which are not found in Ontario. Hence, the canneries sub-sector and related SCC's were excluded. Similarly, only the coating operations of the automotive and automotive parts industries are addressed in this study. Hence, SCC's relating to other processes in the automotive and automotive parts industries were eliminated.

Few problems were encountered in matching the sector and sub-sector definitions to those within the scope of this study. Matching the process definitions, with the exception of boilers, also did not create any problems. Where questions arose we contacted Senes Consultants to ensure that the sub-sector and/or process coverage in terms of SCC's matched emission sources they identified in Ontario.

E.7 BOILERS

Boilers are an integral part of many industrial processes. They are also used to provide space heating for larger buildings. It is not surprising then to find that a number of the SCC's related to boilers. However, Senes advised us that boilers are not important sources of emissions in many of the sectors studied and hence boiler emissions were not included in their estimated emissions for these sectors.

Boilers therefore presented three problems for the analysis:

- . Whether, for a particular economic sector, the boiler aspect should be included or not.
- . Whether boilers used for space heat should be considered.
- . If it was decided to include boiler emissions in a particular sector, how the speciation of VOC and PM emissions obtained from the U.S. should be adjusted to account for the greater use of natural gas and oil in Ontario relative to the United States.

Our approach to these problems is described below. The approach is apparently simplistic, but we considered it better to be consistent in a project with uncertainty, in any case, so prevalent.

E.7.1 Boiler Inclusion in the Analysis

The EPA NEDS database may indicate that boilers are sources of VOC's and PM's in a particular U.S. industrial sector. Regardless of that information, we followed the advice of the consultants who provided the emissions data (Senes) as to whether boilers had in fact been included in their calculations. If boiler emissions were included in the emissions estimates, EPA boiler speciations were used for PM's and VOC's emitted by the sector in question. If boiler emissions were not included in the emissions estimates, the SCC's relating to boilers were dropped.

Eliminating the emissions from boilers had the effect of reducing the percentage of total VOC or PM emissions covered by the selected SCC's below 75 percent of total VOC and PM emissions by that industry in most cases.

E.7.2 Boiler Use for Space Heat

Emissions from boilers used for space heating were excluded in all cases, except to the extent that the boiler would be included as part of the general boiler use in the sector.

E.7.3 Boiler Fuel Conversion, Sectors

We judged it necessary to make boiler fuel conversions in three sectors: electric power generation, pulp and paper, and petroleum refineries.

Ontario Hydro information for the six power generation plants examined in this study indicates that only three fuels are used: lignite coal, bituminous coal, and heavy fuel oil. The EPA data also indicated boilers fueled by wood bark waste, distillate oil and natural gas. We treated these fuels as heavy fuel oil and adjusted emissions as described below.

In the pulp and paper sector, we assumed that wood bark waste, natural gas, and heavy fuel oil are used in Ontario. Where EPA identified the use of coal, we treated these emissions as if they came from heavy fuel oil. For petroleum refineries, we assumed natural gas and heavy fuel oil are used to fuel boilers. Where EPA referred to use of light oil, we converted this to heavy fuel oil.

E.7.4 Boiler Fuel Conversion, Procedure

Next we had to convert emissions from one fuel type to another. We used the following procedure.

Senes provided us with information on VOC and PM emissions per tonne of steam for different fuels by boiler type (i.e., the many different kinds of boiler that are powered by one type of fuel).

VOC and PM emissions per tonne of steam do not vary greatly by boiler type. The emissions per tonne of steam depend much more on the fuel used than on the boiler design. We calculated typical VOC and PM emissions per tonne of steam by fuel type, regardless of the boiler type.

To convert the EPA data from one boiler fuel to another, we started from the premise that the steam required would not change. Then the quantity and composition of the VOC and PM emissions resulting from the generation of that steam were adjusted to reflect the different boiler fuel.

For example, assume the NEDS data for the pulp and paper industry indicated that particulate emissions from bituminous coal-fired boilers amounted to 500 tonnes per year. The steam generated was estimated at $(500 \times 1,000 / 5.35 =) 93,458$ tonnes per year.² Assuming this same 93,458 tonnes of steam was generated by a heavy oil fired boiler, the PM emissions would be $(93,458 \times 0.075 / 1,000 =) 7$ tonnes per year.³ The magnitude of this shift in PM emissions -- from 500 tonnes to 7 tonnes in the example -- indicates why we felt it important to adjust the mix of boiler fuels where possible.

The PM emissions estimated by converting from one boiler fuel to another (bituminous coal to heavy oil) were added to the emissions reported by the NEDS database for the substitute fuel (heavy oil). The SCC profile for boilers using that fuel was assumed to apply to the revised total emissions.

² 500 tonnes of PM $\times 1,000$ kg/tonne divided by PM emissions of 5.35 kg per tonne of steam.

³ 93,458 tonnes of steam $\times 0.075$ kg of PM emissions per tonne of steam/ $1,000$ kg per tonne = 7 tonnes of PM emissions.

These calculations eliminate some SCC profiles -- those for the boiler fuels that have been converted -- from the set of profiles for the industry and assign higher total PM and VOC emissions to other SCC profiles -- those for the substitute fuels -- for that industry. The total emissions of PM and VOC by SCC obtained from the NEDS database, adjusted for the different mix of boiler fuels, are used as weights for the SCC profiles in the calculation of overall PM and VOC emissions profiles for the industry.

This process may appear unsatisfactory. However, the reader should remember that the objective of the speciation process is to define the characteristic proportions of contaminants in the emissions from a particular economic sector. Thus, apparent errors resulting from our adjustments may alter the composition of the VOC or PM emissions speciations somewhat, but will not affect the total amount of such emissions. The amounts are those estimated by Senes.

E.8 CALCULATION OF SPECIATIONS

Having identified the SCC's that account for the bulk of the VOC and PM emissions in the sectors and sub-sectors of interest for this study and having adjusted the process fuels where appropriate, it remained to calculate a VOC and PM speciation for each industry. That was done as follows.

All of the selected SCC's corresponding to a given Canadian SIC were identified. The composition of each of these SCC's was determined from the NEDS database. This lists every chemical that is found in the VOC (PM) emissions by that SCC together with the percent weight of that chemical of total VOC (PM) emitted by that process (SCC) by U.S. plants in 1985. Next, weighted

averages of the same contaminant from different SCC's were combined. This total was used to determine each contaminant's percentage share of the total VOC (PM) emissions for a specific Canadian SIC.

In a few instances, the emissions data provided by Senes Consultants (Appendix D) identifies separately chemicals that are constituents of the PM or VOC emissions. We checked with them to determine whether those chemicals were emitted separately, in addition to the emissions that of that chemical as part of the PM or VOC emissions. Where the emissions were said to be part of the PM or VOC emissions, the quantities of that chemical estimated by the speciation of the PM or VOC emissions were subsequently replaced by Senes' estimate of emissions for the contaminant. This uses the more relevant information generated by Senes, and eliminates double counting of emissions of those contaminants.

E.9 RESULTS

The PM and VOC speciations for the Canadian SIC codes used in this analysis are shown below.

The profiles break down the PM and VOC emissions into their constituent chemicals. Some of those constituent chemicals are Regulation 308 Contaminants. Others are not on the list of 96 chemicals we were asked to consider. Each profile shows the percentage contribution of each Regulation 308 Contaminant and a balance percentage of "other" chemicals making up the profile.

This "other" category typically accounts for most -- usually over 60 percent -- of the PM or VOC emissions in a sector. The relatively large size of this "other" category raised the concern

that potentially harmful contaminants were being overlooked. To allay this concern we provided a list of all VOC and PM chemicals on the NEDS database to the Ministry of the Environment for review. The Ministry was satisfied that the list of contaminants originally specified identified the chemicals of concern. This review led to the addition of three chemicals to the list of contaminants.

Thus, the "other" category can be considered to consist of relatively harmless chemicals. The steps taken to reduce the more hazardous chemicals in the VOC or PM emission streams will have the effect of lowering emissions of these more benign constituents as well at no additional cost. Because of the relatively benign nature of these "other" chemicals no benefits are deemed to be derived from their curtailment.

OPEN PIT MINING

SIC 0611 Gold Mines

PM Contaminant Per Cent

SILICA	31.42
OTHER	68.58
Subtotal	100.00

SIC 0617 Iron Ore Mines

PM Contaminant Per Cent

ARSENIC	2.64
CADMIUM	0.75
CHROMIUM	0.23
FLUORIDE	0.52
MERCURY	0.01
MANGANESE	0.68
NICKEL	0.14
LEAD	4.93
SELENIUM	0.05
SILICA	4.54
TIN	0.20
OTHER	85.30
Subtotal	99.99

FOOD INDUSTRIES

SIC 1011 Meat and Meat Products

PM Contaminant	Per Cent
SILICA	15.00
OTHER	85.00
Subtotal	100.00

VOC Contaminant	Per Cent
BENZENE	0.11
ETHYLBENZENE	0.01
ETHYLENE	0.63
FORMALDEHYDE	0.81
TOLUENE	0.04
OTHER	98.40
Subtotal	100.00

SIC 1012 Poultry Products

PM Contaminant	Per Cent
SILICA	15.00
OTHER	85.00
Subtotal	100.00

VOC Contaminant	Per Cent
OTHER	100.00
Subtotal	100.00

SIC 1021 Fish Products

PM Contaminant	Per Cent
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SILICA	15.00
OTHER	85.00
Subtotal	100.00

SIC 1049 Other Dairy Products (Whey Drying)

PM Contaminant	Per Cent
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ARSENIC	0.23
CADMIUM	0.07
CHROMIUM	0.03
FLUORIDE	0.05
MERCURY	0.01
MANGANESE	0.07
NICKEL	0.03
LEAD	0.68
SELENIUM	0.01
SILICA	13.76
TIN	0.03
OTHER	85.04
Subtotal	100.01

VOC Contaminant	Per Cent
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OTHER	100.00
Subtotal	100.00

PULP AND PAPER AND ALLIED PRODUCTS

SIC 2711 Pulp Industry

PM Contaminant	Per Cent
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ARSENIC	0.01
CADMIUM	0.01
CHROMIUM	0.03
FLUORIDE	1.19
MERCURY	0.08
MANGANESE	0.15
NICKEL	0.03
LEAD	0.01
SELENIUM	0.02
SILICA	0.55
TIN	0.02
OTHER	97.90
Subtotal	100.00

VOC Contaminant	Per Cent
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BENZENE	7.62
ETHYLBENZENE	0.48
ETHYLENE	6.67
FORMALDEHYDE	9.48
TOLUENE	1.00
OTHER	74.74
Subtotal	99.99

SIC 2712 Newsprint Industry

PM Contaminant	Per Cent	VOC Contaminant	Per Cent
ARSENIC	0.01	1,1,1-TRICHLOROETHANE	0.02
CADMIUM	0.01	1,3-BUTADIENE	0.06
CHROMIUM	0.02	ACRYLONITRILE	0.05
FLUORIDE	0.85	BENZENE	9.46
MERCURY	0.05	BUTYL ACRYLATE	0.03
MANGANESE	0.12	BUTYL CELLOSOLVE	0.02
NICKEL	0.43	CARBON TETRACHLORIDE	0.04
LEAD	0.02	CELLOSOLVE	0.02
SELENIUM	0.01	CELLOSOLVE ACETATE	0.02
SILICA	2.03	CHLOROFORM	0.03
TIN	0.02	EPICHLOROHYDRIN	0.02
OTHER	96.43	ETHYLBENZENE	0.73
Subtotal	100.00	ETHYLENE	7.48
		ETHYLENE DIBROMIDE	0.02
		ETHYLENE DICHLORIDE	0.09
		ETHYLENE OXIDE	0.02
		FORMALDEHYDE	4.55
		METHYL ETHYL KETONE	0.11
		METHYL ISOBUTYL KETONE	0.04
		NAPHTHALENE	0.03
		PERCHLOROETHYLENE	0.04
		PHENOL	0.55
		PROPIONALDEHYDE	0.02
		PROPIONIC ACID	0.02
		PROPYLENE OXIDE	0.03
		STYRENE	0.17
		TOLUENE	2.16
		TOLUENE DIISOCYANATE	0.04
		TRICHLOROETHYLENE	0.02
		VINYL CHLORIDE	0.06
		OTHER	74.06
		Subtotal	100.01

SIC 2713 Paperboard Industry

PM Contaminant	Per Cent	VOC Contaminant	Per Cent
ARSENIC	0.01	BENZENE	11.08
CADMIUM	0.01	ETHYLBENZENE	0.43
CHROMIUM	0.01	ETHYLENE	9.75
FLUORIDE	1.18	FORMALDEHYDE	6.69
MERCURY	0.08	TOLUENE	0.76
MANGANESE	0.17	OTHER	71.27
NICKEL	0.50	Subtotal	99.98
LEAD	0.02		
SILICA	2.06		
TIN	0.02		
OTHER	95.92		
Subtotal	99.98		

SIC 2811 Business Forms Printing

VOC Contaminant	Per Cent
METHYL ETHYL KETONE	54.27
METHYL ISOBUTYL KETONE	14.78
TOLUENE	6.48
OTHER	24.47
Subtotal	100.00

SIC 2819 Other Commercial Printing

PM Contaminant	Per Cent	VOC Contaminant	Per Cent
ARSENIC	1.04	BENZENE	0.04
CADMIUM	0.34	BUTYL CELLOSOLVE	0.11
CHROMIUM	0.12	CELLOSOLVE	0.01
FLUORIDE	0.22	ETHYLBENZENE	3.77
MERCURY	0.05	ETHYLENE	0.12
MANGANESE	0.32	ETHYLENE DIBROMIDE	0.07
NICKEL	0.12	FORMALDEHYDE	1.22
LEAD	3.10	METHYL ETHYL KETONE	5.51
SELENIUM	0.03	METHYL ISOBUTYL KETONE	2.71
SILICA	8.36	TOLUENE	3.73
TIN	0.15	OTHER	82.67
OTHER	86.17	Subtotal	99.96
Subtotal	100.02		

SIC 2821 Plate Making, Typesetting and Bindery

PM Contaminant	Per Cent	VOC Contaminant	Per Cent
CADMIUM	0.01	1,1,1-TRICHLOROETHANE	0.03
FLUORIDE	0.36	1,3-BUTADIENE	0.05
MANGANESE	0.04	ACRYLONITRILE	0.04
NICKEL	0.01	BENZENE	0.20
LEAD	0.01	BUTYL ACRYLATE	0.03
SILICA	0.21	BUTYL CELLOSOLVE	6.06
TIN	0.01	CARBON TETRACHLORIDE	0.05
OTHER	99.35	CELLOSOLVE	0.03
Subtotal	100.00	CELLOSOLVE ACETATE	0.03
		CHLOROFORM	0.04
		EPICHLOROHYDRIN	0.03
		ETHYLBENZENE	0.55
		ETHYLENE	0.20
		ETHYLENE DIBROMIDE	0.03
		ETHYLENE DICHLORIDE	0.04
		ETHYLENE OXIDE	0.03
		FORMALDEHYDE	0.11
		METHYL ETHYL KETONE	0.59
		METHYL ISOBUTYL KETONE	0.37
		NAPHTHALENE	0.01
		PERCHLOROETHYLENE	0.05
		PHENOL	0.03
		PROPIONALDEHYDE	0.03
		PROPIONIC ACID	0.03
		PROPYLENE OXIDE	0.04
		STYRENE	0.08
		TOLUENE	35.36
		TOLUENE DIISOCYANATE	0.05
		TRICHLOROETHYLENE	0.03
		VINYL CHLORIDE	0.03
		OTHER	55.77
		Subtotal	100.02

SIC 2841 Newspaper, Magazine and Periodical Publishing

VOC Contaminant	Per Cent
BUTYL CELLOSOLVE	0.43
ETHYLBENZENE	0.28
ETHYLENE	0.03
ETHYLENE DIBROMIDE	0.14
FORMALDEHYDE	0.36
METHYL ETHYL KETONE	12.16
METHYL ISOBUTYL KETONE	4.79
TOLUENE	6.50
OTHER	75.31
Subtotal	100.00

SIC 2849 Other Combined Publishing and
Printing Industries

VOC Contaminant	Per Cent
ETHYLBENZENE	6.00
OTHER	94.00
Subtotal	100.00

IRON AND STEEL INDUSTRIES

SIC 2911 Ferro-Alloys

PM Contaminant	Per Cent
ARSENIC	0.21
CADMIUM	0.20
CHROMIUM	1.38
MANGANESE	0.29
NICKEL	0.10
LEAD	3.56
SELENIUM	0.02
SILICA	6.61
TIN	0.01
OTHER	87.61
Subtotal	99.99

VOC Contaminant	Per Cent
1,1,1-TRICHLOROETHANE	0.04
1,3-BUTADIENE	0.38
ACRYLONITRILE	0.05
BENZENE	9.28
BUTYL ACRYLATE	0.04
BUTYL CELLOSOLVE	0.04
CARBON TETRACHLORIDE	0.06
CELLOSOLVE	0.03
CELLOSOLVE ACETATE	0.03
CHLOROFORM	0.05
EPICHLOROHYDRIN	0.04
ETHYLBENZENE	0.06
ETHYLENE	19.56
ETHYLENE DIBROMIDE	0.04
ETHYLENE DICHLORIDE	0.05
ETHYLENE OXIDE	0.04
FORMALDEHYDE	0.15
METHYL ETHYL KETONE	0.11
METHYL ISOBUTYL KETONE	0.05
NAPHTHALENE	0.02
PERCHLOROETHYLENE	0.07
PHENOL	0.04
PROPIONALDEHYDE	0.04
PROPIONIC ACID	0.04
PROPYLENE OXIDE	0.05
STYRENE	0.11
TOLUENE	0.64
TOLUENE DIISOCYANATE	0.06
TRICHLOROETHYLENE	0.04
VINYL CHLORIDE	0.04
OTHER	68.75
Subtotal	100.00

SIC 2912 Steel Foundries

PM Contaminant	Per Cent	VOC Contaminant	Per Cent
ARSENIC	0.02	1,1,1-TRICHLOROETHANE	0.43
CADMIUM	0.03	1,3-BUTADIENE	0.67
CHROMIUM	1.36	ACRYLONITRILE	0.58
MANGANESE	3.35	BENZENE	2.82
NICKEL	1.04	BUTYL ACRYLATE	0.43
LEAD	0.50	BUTYL CELLOSOLVE	0.44
SILICA	2.92	CARBON TETRACHLORIDE	0.65
TIN	0.01	CELLOSOLVE	0.36
OTHER	90.75	CELLOSOLVE ACETATE	0.36
Subtotal	99.98	CHLOROFORM	0.51
		EPICHLOROHYDRIN	0.42
		ETHYLBENZENE	0.65
		EIHYLENE	2.86
		EIHYLENE DIBROMIDE	0.42
		EIHYLENE DICHLORIDE	0.58
		EIHYLENE OXIDE	0.38
		FORMALDEHYDE	1.55
		METHYL EIHYL KETONE	1.22
		METHYL ISOBUTYL KETONE	0.56
		NAPHTHALENE	0.18
		PERCHLOROETHYLENE	0.70
		PHENOL	0.44
		PROPIONALDEHYDE	0.42
		PROPIONIC ACID	0.40
		PROPYLENE OXIDE	0.50
		STYRENE	1.20
		TOLUENE	2.04
		TOLUENE DIISOCYANATE	0.66
		TRICHLOROBENZENES	0.01
		TRICHLOROETHYLENE	0.43
		VINYL CHLORIDE	0.42
		OTHER	76.67
		Subtotal	99.96

SIC 2919 Other Primary Steel Industries

PM Contaminant	Per Cent	VOC Contaminant	Per Cent
ARSENIC	0.08	1,3-BUTADIENE	0.18
CADMIUM	0.09	ACRYLONITRILE	0.19
CHROMIUM	0.76	BENZENE	2.16
FLUORIDE	0.07	BUTYL ACRYLATE	0.04
MANGANESE	5.06	BUTYL CELLOSOLVE	2.09
NICKEL	0.20	CARBON TETRACHLORIDE	0.06
LEAD	1.63	CHLOROFORM	0.01
SELENIUM	0.01	ETHYLBENZENE	0.30
SILICA	0.85	ETHYLENE	1.76
OTHER	91.25	ETHYLENE DICHLORIDE	0.50
Subtotal	100.00	ETHYLENE OXIDE	0.01
		FORMALDEHYDE	0.54
		METHYL ETHYL KETONE	2.56
		METHYL ISOBUTYL KETONE	1.79
		NAPHTHALENE	0.03
		PHENOL	0.33
		STYRENE	0.89
		TOLUENE	20.36
		TRICHLOROBENZENES	0.01
		VINYL CHLORIDE	0.32
		OTHER	65.88
		Subtotal	100.01

FOUNDRIES

SIC 2941 Iron Foundries

PM Contaminant	Per Cent	VOC Contaminant	Per Cent
ARSENIC	0.01	1,1,1-TRICHLOROETHANE	0.05
CADMIUM	0.01	1,3-BUTADIENE	0.08
CHROMIUM	0.08	ACRYLONITRILE	0.07
MANGANESE	3.24	BENZENE	1.42
NICKEL	0.10	BUTYL ACRYLATE	0.05
LEAD	0.38	BUTYL CELLOSOLVE	4.04
SILICA	13.58	CARBON TETRACHLORIDE	0.08
OTHER	82.59	CELLOSOLVE	0.04
Subtotal	99.99	CELLOSOLVE ACETATE	0.04
		CHLOROFORM	0.06
		EPICHLOROHYDRIN	0.05
		ETHYLBENZENE	0.41
		ETHYLENE	0.36
		ETHYLENE DIBROMIDE	0.05
		ETHYLENE DICHLORIDE	0.07
		ETHYLENE OXIDE	0.05
		FORMALDEHYDE	0.21
		METHYL ETHYL KETONE	0.48
		METHYL ISOBUTYL KETONE	0.29
		NAPHTHALENE	0.02
		PERCHLOROETHYLENE	0.09
		PHENOL	3.13
		PROPIONALDEHYDE	0.05
		PROPIONIC ACID	0.05
		PROPYLENE OXIDE	0.06
		STYRENE	0.15
		TOLUENE	23.97
		TOLUENE DIISOCYANATE	0.08
		TRICHLOROETHYLENE	0.05
		VINYL CHLORIDE	0.05
		OTHER	64.34
		Subtotal	99.94

SIC 2971 Copper and Copper Alloy
Rolling, Casting and Extruding

PM Contaminant	Per Cent	VOC Contaminant	Per Cent
ARSENIC	0.03	1,1,1-TRICHLOROETHANE	6.93
CADMUM	0.01	BENZENE	0.31
CHROMIUM	0.02	BUTYL CELLOSOLVE	3.33
MANGANESE	0.71	ETHYLBENZENE	0.28
NICKEL	0.02	METHYL ETHYL KETONE	0.62
LEAD	0.37	METHYL ISOBUTYL KETONE	0.18
SILICA	3.60	NAPHTHALENE	0.01
TIN	0.01	PERCHLOROETHYLENE	18.30
OTHER	95.25	TOluene	22.03
Subtotal	100.02	TRICHLOROETHYLENE	6.55
		OTHER	41.45
		Subtotal	99.99

SIC 2999 Other Rolled, Cast and Extruded
Non-Ferrous Metal Products

PM Contaminant	Per Cent	VOC Contaminant	Per Cent
ARSENIC	0.06	PERCHLOROETHYLENE	100.00
CADMUM	0.05	Subtotal	100.00
CHROMIUM	1.85		
MANGANESE	0.61		
NICKEL	0.53		
LEAD	0.95		
SILICA	4.80		
TIN	0.06		
OTHER	91.08		
Subtotal	99.99		

NON-FERROUS METAL SMELTING AND REFINING

SIC 2959 Other Primary Smelting and Refining of Non-Ferrous Metal

PM Contaminant	Per Cent	VOC Contaminant	Per Cent
ARSENIC	25.48	BENZENE	4.01
CADMIUM	1.46	ETHYLENE	0.01
CHROMIUM	0.22	FORMALDEHYDE	7.98
FLUORIDE	1.47	TOLUENE	2.00
MERCURY	0.04	OTHER	85.99
MANGANESE	0.32	Subtotal	99.99
NICKEL	0.09		
LEAD	12.25		
SELENIUM	0.23		
SILICA	2.25		
TIN	0.32		
OTHER	55.86		
Subtotal	99.99		

MOTOR VEHICLE INDUSTRIES

SIC 3231 Motor Vehicles and Motor Vehicle Parts and Accessories Surface Coating

PM Contaminant	Per Cent	VOC Contaminant	Per Cent
CADMIUM	0.05	BENZENE	1.04
CHROMIUM	0.05	ETHYLBENZENE	8.68
NICKEL	0.05	TOLUENE	20.12
OTHER	99.85	OTHER	70.16
Subtotal	100.00	Subtotal	100.00

SIC 3254 Motor Vehicle Steering and
Suspension Parts

PM Contaminant	Per Cent	VOC Contaminant	Per Cent
OTHER	99.99	1,1,1-TRICHLOROETHANE	1.89
Subtotal	99.99	1,3-BUTADIENE	0.96
		ACRYLONITRILE	0.01
		BENZENE	0.39
		BUTYL CELLOSOLVE	0.76
		ETHYLBENZENE	2.33
		ETHYLENE	2.29
		ETHYLENE DICHLORIDE	0.02
		FORMALDEHYDE	0.44
		METHYL ETHYL KETONE	0.17
		METHYL ISOBUTYL KETONE	0.04
		PERCHLOROETHYLENE	0.63
		PHENOL	0.01
		PROPIONALDEHYDE	0.01
		STYRENE	0.04
		TOLUENE	12.76
		TRICHLOROETHYLENE	1.79
		VINYL CHLORIDE	0.01
		OTHER	75.45
		Subtotal	100.00

INORGANIC CHEMICAL MANUFACTURING

SIC 3511 Domestic Clay Products

PM Contaminant	Per Cent	VOC Contaminant	Per Cent
ARSENIC	0.01	BENZENE	3.76
CADMIUM	0.01	ETHYLBENZENE	3.29
CHROMIUM	0.17	ETHYLENE	0.08
FLUORIDE	0.03	FORMALDEHYDE	2.96
MANGANESE	0.07	NAPHTHALENE	0.10
NICKEL	0.06	TOLUENE	5.59
LEAD	0.17	OTHER	84.21
SELENIUM	0.06	Subtotal	99.99
SILICA	7.67		
OTHER	91.76		
Subtotal	100.01		

SIC 3512 Imported Clay Products

PM Contaminant	Per Cent	VOC Contaminant	Per Cent
ARSENIC	0.01	1,3-BUTADIENE	0.01
CADMIUM	0.01	ACRYLONITRILE	0.01
CHROMIUM	0.12	BENZENE	0.09
FLUORIDE	0.02	BUTYL CELLOSOLVE	2.63
MANGANESE	0.04	ETHYLBENZENE	0.81
NICKEL	0.04	ETHYLENE	0.08
LEAD	0.11	ETHYLENE DIBROMIDE	0.09
SELENIUM	0.04	ETHYLENE DICHLORIDE	0.02
SILICA	6.72	FORMALDEHYDE	0.07
OTHER	92.90	METHYL ETHYL KETONE	2.56
Subtotal	100.01	METHYL ISOBUTYL KETONE	1.62
		PHENOL	0.01
		STYRENE	0.04
		TOLUENE	25.71
		VINYL CHLORIDE	0.01
		OTHER	66.22
		Subtotal	99.98

SIC 3521 Hydraulic Cement

PM Contaminant	Per Cent	VOC Contaminant	Per Cent
CADMIUM	0.01	1,1,1-TRICHLOROETHANE	0.25
CHROMIUM	0.22	1,3-BUTADIENE	0.39
FLUORIDE	0.12	ACRYLONITRILE	0.34
MANGANESE	0.02	BENZENE	2.60
NICKEL	0.03	BUTYL ACRYLATE	0.25
LEAD	0.83	BUTYL CELLOSOLVE	0.26
SELENIUM	0.01	CARBON TETRACHLORIDE	0.38
SILICA	5.48	CELLOSOLVE	0.21
OTHER	93.29	CELLOSOLVE ACETATE	0.21
Subtotal	100.01	CHLOROFORM	0.30
		EPICHLOROHYDRIN	0.25
		ETHYLBENZENE	0.56
		EIHYLENE	2.15
		EIHYLENE DIBROMIDE	0.25
		EIHYLENE DICHLORIDE	0.34
		EIHYLENE OXIDE	0.22
		FORMALDEHYDE	4.95
		METHYL EIHYL KETONE	0.72
		METHYL ISOBUTYL KETONE	0.33
		NAPHTHALENE	0.27
		PERCHLOROETHYLENE	0.41
		PHENOL	0.26
		PROPIONALDEHYDE	0.25
		PROPIONIC ACID	0.24
		PROPYLENE OXIDE	0.29
		STYRENE	0.71
		TOLUENE	1.76
		TOLUENE DIISOCYANATE	0.39
		TRICHLOROBENZENES	0.01
		TRICHLOROETHYLENE	0.25
		VINYL CHLORIDE	0.25
		OTHER	79.91
		Subtotal	99.96

3571 Abrasives

PM Contaminant	Per Cent	VOC Contaminant	Per Cent
ARSENIC	0.47	1,1,1-TRICHLOROETHANE	0.02
CADMIUM	0.15	1,3-BUTADIENE	0.13
CHROMIUM	0.05	ACRYLONITRILE	0.13
FLUORIDE	0.10	BENZENE	1.26
MERCURY	0.02	BUTYL ACRYLATE	0.05
MANGANESE	0.14	BUTYL CELLOSOLVE	0.02
NICKEL	0.05	CARBON TETRACHLORIDE	0.07
LEAD	1.40	CELLOSOLVE	0.02
SELENIUM	0.01	CELLOSOLVE ACETATE	0.02
SILICA	3.47	CHLOROFORM	0.03
TIN	0.06	EPICHLOROHYDRIN	0.02
OTHER	94.08	ETHYLBENZENE	0.84
Subtotal	100.00	ETHYLENE	1.09
		ETHYLENE DIBROMIDE	0.74
		ETHYLENE DICHLORIDE	0.30
		ETHYLENE OXIDE	0.03
		FORMALDEHYDE	0.37
		METHYL ETHYL KETONE	3.47
		METHYL ISOBUTYL KETONE	0.06
		NAPHTHALENE	0.02
		PERCHLOROETHYLENE	0.04
		PHENOL	0.20
		PROPIONALDEHYDE	0.02
		PROPIONIC ACID	0.02
		PROPYLENE OXIDE	0.03
		STYRENE	0.54
		TOLUENE	12.36
		TOLUENE DIISOCYANATE	0.03
		TRICHLOROBENZENES	0.01
		TRICHLOROETHYLENE	0.02
		VINYL CHLORIDE	0.19
		OTHER	77.84
		Subtotal	99.99

SIC 3581 Lime

PM Contaminant	Per Cent	VOC Contaminant	Per Cent
ARSENIC	0.01	BENZENE	1.38
CADMIUM	0.01	ETHYLBENZENE	0.81
CHROMIUM	0.17	ETHYLENE	1.67
FLUORIDE	0.03	FORMALDEHYDE	15.19
MANGANESE	0.07	TOLUENE	1.48
NICKEL	0.06	OTHER	79.46
LEAD	0.17	Subtotal	99.99
SELENIUM	0.06		
SILICA	7.67		
OTHER	91.76		
Subtotal	100.01		

SIC 3711 Industrial Inorganic Chemicals
(NEC)

PM Contaminant	Per Cent	VOC Contaminant	Per Cent
CADMIUM	0.04	1,1,1-TRICHLOROETHANE	0.54
CHROMIUM	0.01	1,3-BUTADIENE	0.56
MANGANESE	0.03	ACRYLONITRILE	0.23
NICKEL	0.04	BENZENE	3.19
LEAD	0.02	BUTYL ACRYLATE	0.06
SELENIUM	0.01	BUTYL CELLOSOLVE	0.01
SILICA	1.62	CARBON TETRACHLORIDE	0.08
TIN	0.01	CHLOROFORM	0.02
OTHER	98.23	EPICHLOROHYDRIN	0.01
Subtotal	100.01	ETHYLBENZENE	0.72
		ETHYLENE	4.21
		ETHYLENE DIBROMIDE	0.01
		ETHYLENE DICHLORIDE	2.10
		ETHYLENE OXIDE	0.02
		FORMALDEHYDE	0.11
		METHYL ETHYL KETONE	0.49
		METHYL ISOBUTYL KETONE	0.07
		PERCHLOROETHYLENE	0.19
		PHENOL	0.37
		PROPIONALDEHYDE	0.01
		PROPIONIC ACID	0.01
		PROPYLENE OXIDE	0.01
		STYRENE	5.74
		TOLUENE	0.85
		TOLUENE DIISOCYANATE	0.01
		TRICHLOROETHYLENE	0.51
		VINYL CHLORIDE	0.38
		OTHER	79.52
		Subtotal	100.03

SIC 3721 Chemical Fertilizer and
Fertilizer Materials

PM Contaminant	Per Cent	VOC Contaminant	Per Cent
ARSENIC	0.05	1,1,1-TRICHLOROETHANE	0.01
CADMIUM	0.05	1,3-BUTADIENE	0.02
CHROMIUM	0.03	ACRYLONITRILE	36.80
FLUORIDE	0.01	BENZENE	2.73
MANGANESE	0.09	BUTYL ACRYLATE	0.07
NICKEL	0.04	BUTYL CELLOSOLVE	0.01
LEAD	0.16	CARBON TETRACHLORIDE	0.10
SELENIUM	0.03	CELLOSOLVE	0.01
SILICA	4.04	CELLOSOLVE ACETATE	0.01
TIN	0.02	CHLOROFORM	0.03
OTHER	95.46	EPICHLOROHYDRIN	0.01
Subtotal	99.98	ETHYLBENZENE	0.19
		ETHYLENE	2.31
		ETHYLENE DIBROMIDE	0.01
		ETHYLENE DICHLORIDE	0.69
		ETHYLENE OXIDE	0.03
		FORMALDEHYDE	0.78
		METHYL ETHYL KETONE	0.55
		METHYL ISOBUTYL KETONE	0.08
		NAPHTHALENE	0.01
		PERCHLOROETHYLENE	0.02
		PHENOL	0.45
		PROPIONALDEHYDE	0.01
		PROPIONIC ACID	0.01
		PROPYLENE OXIDE	0.02
		STYRENE	25.44
		TOLUENE	0.73
		TOLUENE DIISOCYANATE	0.02
		TRICHLOROETHYLENE	0.01
		VINYL CHLORIDE	0.44
		XYLENE BASE ACIDS	0.01
		OTHER	28.35
		Subtotal	99.96

PETROLEUM REFINERIES

SIC 3611 Petroleum Refineries

PM Contaminant Per Cent

ARSENIC	0.01
CHROMIUM	0.14
FLUORIDE	0.02
MANGANESE	0.03
NICKEL	1.51
LEAD	0.07
SELENIUM	0.13
SILICA	8.57
OTHER	89.51
Subtotal	99.99

VOC Contaminant

BENZENE	2.60
ETHYLBENZENE	0.36
ETHYLENE	0.01
FORMALDEHYDE	6.69
NAPHTHALENE	0.07
STYRENE	0.01
TOLUENE	1.75
OTHER	88.51
Subtotal	100.00

ASPHALT PAVING INDUSTRY

SIC 3699 Asphalt Paving Industry

PM Contaminant Per Cent

ARSENIC	0.01
CADMIUM	0.01
CHROMIUM	0.15
FLUORIDE	0.02
MANGANESE	0.07
NICKEL	0.05
LEAD	0.15
SELENIUM	0.06
SILICA	6.73
OTHER	92.75
Subtotal	100.00

VOC Contaminant

1,3-BUTADIENE	0.01
ACRYLONITRILE	0.01
BENZENE	2.95
CARBON TETRACHLORIDE	0.01
CHLOROFORM	0.01
ETHYLBENZENE	1.25
ETHYLENE	0.03
ETHYLENE DICHLORIDE	0.01
FORMALDEHYDE	5.53
METHYL ETHYL KETONE	0.01
METHYL ISOBUTYL KETONE	0.01
NAPHTHALENE	1.02
PERCHLOROETHYLENE	0.01
PROPYLENE OXIDE	0.01
STYRENE	0.01
TOLUENE	4.28
TOLUENE DIISOCYANATE	0.01
OTHER	84.81
Subtotal	99.98

ORGANIC CHEMICAL PRODUCTS

SIC 3712 Industrial Organic Chemicals
(NEC)

PM Contaminant	Per Cent	VOC Contaminant	Per Cent
ARSENIC	0.01	1,1,1-TRICHLOROETHANE	0.01
CADMIUM	0.04	1,3-BUTADIENE	2.08
CHROMIUM	0.02	ACRYLONITRILE	4.11
MERCURY	0.16	BENZENE	4.32
MANGANESE	0.09	BUTYL ACRYLATE	0.08
NICKEL	0.06	BUTYL CELLOSOLVE	0.01
LEAD	0.27	CARBON TETRACHLORIDE	0.12
SELENIUM	0.02	CHLOROFORM	0.02
SILICA	4.45	EPICHLOROHYDRIN	0.01
TIN	0.05	ETHYLBENZENE	0.50
OTHER	94.84	ETHYLENE	16.89
Subtotal	100.01	ETHYLENE DIBROMIDE	0.01
		ETHYLENE DICHLORIDE	2.36
		ETHYLENE OXIDE	0.03
		FORMALDEHYDE	0.05
		METHYL ETHYL KETONE	2.72
		METHYL ISOBUTYL KETONE	0.09
		PERCHLOROETHYLENE	0.01
		PHENOL	0.87
		PROPIONALDEHYDE	0.01
		PROPIONIC ACID	0.01
		PROPYLENE OXIDE	0.02
		STYRENE	5.50
		TOLUENE	0.80
		TOLUENE DIISOCYANATE	0.01
		TRICHLOROETHYLENE	0.01
		VINYL CHLORIDE	3.16
		XYLENE BASE ACIDS	0.01
		OTHER	56.17
		Subtotal	100.00

SIC 3731 Plastics and Synthetics Resins

PM Contaminant	Per Cent	VOC Contaminant	Per Cent
CADMIUM	0.04	BENZENE	0.70
CHROMIUM	0.02	FORMALDEHYDE	1.41
MANGANESE	0.12	TOLUENE	0.35
NICKEL	0.03	OTHER	97.55
LEAD	0.01	Subtotal	100.01
SELENIUM	0.02		
SILICA	5.95		
TIN	0.03		
OTHER	93.80		
Subtotal	100.02		

SIC 3751 Paint and Varnish

PM Contaminant	Per Cent	VOC Contaminant	Per Cent
CADMIUM	0.03	1,3-BUTADIENE	10.45
CHROMIUM	0.02	BENZENE	0.01
MANGANESE	0.12	ETHYLENE	0.01
NICKEL	0.02	FORMALDEHYDE	0.01
LEAD	0.01	METHYL ETHYL KETONE	7.61
SELENIUM	0.01	PHENOL	5.36
SILICA	5.93	STYRENE	6.97
TIN	0.03	TOLUENE	31.70
OTHER	93.81	OTHER	37.84
Subtotal	99.98	Subtotal	99.96

SIC 3791 Printing Ink

PM Contaminant	Per Cent	VOC Contaminant	Per Cent
CADMIUM	0.04	ETHYLBENZENE	3.00
CHROMIUM	0.02	METHYL ETHYL KETONE	5.00
MANGANESE	0.12	OTHER	92.00
NICKEL	0.03	Subtotal	100.00
LEAD	0.01		
SELENIUM	0.02		
SILICA	5.95		
TIN	0.03		
OTHER	93.80		
Subtotal	100.02		

SIC 3792 Adhesives

PM Contaminant	Per Cent	VOC Contaminant	Per Cent
CADMIUM	0.05	1,3-BUTADIENE	0.07
CHROMIUM	0.04	ACRYLONITRILE	0.07
MANGANESE	0.04	BENZENE	0.82
NICKEL	0.04	BUTYL ACRYLATE	0.02
SELENIUM	0.01	BUTYL CELLOSOLVE	0.09
SILICA	1.98	CARBON TETRACHLORIDE	0.02
TIN	0.01	CELLOSOLVE	0.57
OTHER	97.84	CELLOSOLVE ACETATE	0.57
Subtotal	100.01	ETHYLBENZENE	0.12
		ETHYLENE	0.69
		ETHYLENE DIBROMIDE	0.01
		ETHYLENE DICHLORIDE	0.19
		ETHYLENE OXIDE	0.57
		FORMALDEHYDE	0.21
		METHYL ETHYL KETONE	1.08
		METHYL ISOBUTYL KETONE	0.15
		NAPHTHALENE	0.01
		PHENOL	9.03
		STYRENE	0.35
		TOLUENE	1.32
		VINYL CHLORIDE	0.12
		OTHER	83.89
		Subtotal	99.97

SIC 3799 Other Chemical Products (NEC)

PM Contaminant	Per Cent	VOC Contaminant	Per Cent
CADMIUM	0.03	ACRYLONITRILE	0.11
CHROMIUM	0.05	BENZENE	0.74
MANGANESE	0.05	BUTYL ACRYLATE	0.01
NICKEL	0.07	CARBON TETRACHLORIDE	0.02
LEAD	0.01	ETHYLBENZENE	0.04
SELENIUM	0.05	ETHYLENE	0.91
SILICA	3.05	ETHYLENE DICHLORIDE	0.17
TIN	0.01	ETHYLENE OXIDE	0.08
OTHER	96.70	FORMALDEHYDE	0.03
Subtotal	100.02	METHYL ETHYL KETONE	0.13
		METHYL ISOBUTYL KETONE	0.02
		PHENOL	10.44
		PROPYLENE OXIDE	0.02
		STYRENE	0.32
		TOLUENE	0.19
		VINYL CHLORIDE	0.12
		XYLENE BASE ACIDS	0.02
		OTHER	86.62
		Subtotal	99.99

ELECTRIC POWER SYSTEMS

SIC 4911 Electric Power Systems - Coal and Heavy Oil Fired Generating Stations

PM Contaminant	Per Cent	VOC Contaminant	Per Cent
ARSENIC	0.05	1,3-BUTADIENE	0.28
CHROMIUM	0.06	BENZENE	0.37
MERCURY	0.01	ETHYLBENZENE	5.88
MANGANESE	0.04	ETHYLENE	1.87
NICKEL	0.25	FORMALDEHYDE	14.19
LEAD	0.17	PROPIONALDEHYDE	0.01
SELENIUM	0.02	TOLUENE	2.96
SILICA	20.06	OTHER	74.39
TIN	0.01	Subtotal	99.95
OTHER	79.32		
Subtotal	99.99		

WASTE DISPOSAL INDUSTRIES

SIC 4999 Hospital Incinerators

PM Contaminant	Per Cent
ARSENIC	0.01
CADMIUM	0.06
CHROMIUM	0.02
MERCURY	2.67
MANGANESE	0.04
NICKEL	0.01
LEAD	4.12
TIN	0.44
OTHER	92.64
Subtotal	100.01

SIC 4999 Municipal and Commercial Incinerators

PM Contaminant	Per Cent	VOC Contaminant	Per Cent
ARSENIC	0.02	BENZENE	7.28
CADMIUM	0.09	ETHYLENE	9.27
CHROMIUM	0.03	OTHER	83.43
FLUORIDE	0.02	Subtotal	99.98
MERCURY	3.99		
MANGANESE	0.07		
NICKEL	0.01		
LEAD	6.15		
SILICA	0.05		
TIN	0.66		
OTHER	88.93		
Subtotal	100.02		

SIC 4999 Sewage Sludge Incinerators

PM Contaminant	Per Cent	VOC Contaminant	Per Cent
CADMIUM	0.83	BENZENE	7.70
CHROMIUM	0.58	ETHYLENE	8.70
MANGANESE	0.21	OTHER	83.60
LEAD	2.94	Subtotal	100.00
SELENIUM	0.15		
SILICA	4.77		
TIN	1.39		
OTHER	89.13		
Subtotal	100.00		

DRY CLEANING ESTABLISHMENTS

SIC 9721 Dry Cleaners

PM Contaminant	Per Cent	VOC Contaminant	Per Cent
ARSENIC	1.18	BENZENE	0.03
CADMIUM	0.38	ETHYLBENZENE	0.16
CHROMIUM	0.13	FORMALDEHYDE	0.07
FLUORIDE	0.24	NAPHTHALENE	0.16
MERCURY	0.05	PERCHLOROETHYLENE	13.23
MANGANESE	0.34	PHENOL	4.93
NICKEL	0.13	TOLUENE	0.25
LEAD	3.50	OTHER	81.20
SELENIUM	0.03	Subtotal	100.03
SILICA	8.67		
TIN	0.16		
OTHER	85.19		
Subtotal	100.00		

APPENDIX F

Dispersion Modelling

TABLE OF CONTENTS

	<u>Page</u>
F.1 INTRODUCTION	F - 1
F.1.1 Organization of the Work	F - 1
F.1.2 Acknowledgement	F - 1
F.2 SELECTION OF A DISPERSION MODEL	F - 2
F.2.1 Proposed Dispersion Model	F - 2
F.2.2 Ministry of the Environment's Models	F - 2
F.3 SELECTION OF LOCATIONS	F - 3
F.3.1 Introduction	F - 3
F.3.2 Climatological Data Requirements	F - 4
F.3.3 Approach to the Selection of Locations	F - 5
F.3.4 Wind Speed and Direction Comparisons	F - 6
F.3.5 Selection Criteria	F - 6
F.3.6 Selection of Locations	F - 9
F.4 COMPIRATION OF METEOROLOGICAL DATA	F - 14
F.4.1 Need to Select a Representative Year	F - 14
F.4.2 Snow Cover	F - 15
F.4.3 Selection of the Representative Year	F - 16
F.4.4 Compilation of Climatological Input Data:	
Hourly Station Data	F - 16
F.4.5 GMT Conversion	F - 17
F.4.6 Cloud Cover	F - 17
F.4.7 The Snow Record	F - 17
F.4.8 Wind	F - 18
F.4.9 Wind Direction	F - 18
F.4.10 Upper Air Data	F - 18
F.4.11 Mixing Heights: U.S. Locations	F - 19
F.4.12 Mixing Heights: Canadian Locations	F - 19
F.4.13 Missing Data Flags	F - 20
F.4.14 Negative or Missing Mixing Height Flags	F - 20
F.4.15 Limitations of the Meteorological Database	F - 20
F.5 EMISSION SOURCE CHARACTERISTICS	F - 22
F.5.1 Building Sources	F - 22
F.5.2 Implications of the Assumed Building Source Characteristics	F - 23
F.5.3 Elevated Sources	F - 24
F.5.4 Near-Lake Sources	F - 25
F.6 THE RECEPTOR GRID	F - 25
F.7 QUALITY ASSURANCE	F - 27
F.7.1 Input Quality Control	F - 27
F.7.2 Output Quality Control	F - 27
F.8 REFERENCES	F - 29

F.1 INTRODUCTION

This appendix describes the dispersion modelling work performed to estimate grids for annual average concentration of air emissions in various parts of Ontario.

F.1.1 Organization of the Work

The principal steps in the work are:

- selection of a model;
- selection of locations for which the model is run;
- compilation of required meteorological data for each location;
- specification of source characteristics; and
- quality assurance checks of the model results.

The approach taken to each of these steps is outlined in the following sections.

F.1.2 Acknowledgement

We are grateful for the valuable assistance provided by the Air and Meteorology Section of the Ontario Ministry of the Environment in the use of their proposed dispersion models and advice in development of input parameters. In particular we would like thank Drs. P.K. Misra, R.N. Bloxam, H. Sahota, and L. Bradizza.

We also appreciate the assistance of staff of the Canadian Climate Centre, Atmospheric Environment Service, Environment Canada and U.S. National Climatic Data Centre.

F.2 SELECTION OF A DISPERSION MODEL

F.2.1 Proposed Dispersion Model

Our original proposal described a regulatory dispersion model presently in use in the Province of Alberta. This model was a variant of the existing Ontario regulatory model (a Pasquill and Gifford type). The multi-source, receptor version of the Alberta model was considered superior in many respects to the existing Ontario regulatory model and thus to be preferred.

Due to demand generated by widespread use of Pasquill-Gifford models, Environment Canada has developed the STAR (STability ARray) program to generate the simplified climatological input data used by these models. Typical input consists of frequency distributions of wind direction, wind speeds, and the Pasquill stability classes (A, B, C, etc.).

F.2.2 Ministry of the Environment's Models

In discussions with the Ontario Ministry of the Environment's Atmospheric Model Development Unit, during the early stages of this project, it was agreed that use of models currently under development in Ontario would be preferred. The models under development were far superior to the Pasquill-type models. The only relative shortcomings of the newer models were in the ease of use. For example, meteorological input data are in the form of detailed hourly meteorological observations. This represents a quantum leap in the quantity of data to be handled and gave rise to considerable complications in data transfer and data management.

A development version of the Ministry's multi-source, (GAS) model was released to the study team in early June. This helped

facilitate data conversion program development. A final "pre-public-release" version was released to the study team on June 21, 1988. That version was used to execute the modelling runs.

Some minor modification to the meteorological parameter calculation program (MET) provided by the Ministry was undertaken to flag additional meteorological cases as invalid (so these cases would not be calculated). Program and data conversion development are described in more detail in subsequent sections.

A full discussion of the new models is presented in Appendix H of the Clean Air Program Discussion Paper issued by the Ontario Ministry of the Environment in late 1987 (Environment Ontario, 1987).

F.3 SELECTION OF LOCATIONS

F.3.1 Introduction

To determine the public benefits of the proposed revisions to Regulation 308, it is necessary to determine the dispersion of emissions of each of the 96 specified contaminants emitted by each of the over 3,500 sources identified. In principle, each source must be modelled separately because the source characteristics and meteorological conditions are unique. In practice that is impossible due to lack of data and the magnitude of the effort it would require.

The availability of climatological information allows only a limited number of sites to be modelled; those for which the required input data can be compiled. The dispersion patterns modelled for those locations are then applied to all sources

within the area to which those climatological characteristics apply. This, in turn, requires that standard characteristics be assumed for the emission sources. The use of standard source characteristics is not a major concern since the required information is, with very rare exceptions, not available in any case. The source characteristic assumptions are discussed in Section F.5 below. Here we review the procedures used to identify the locations with different climatological characteristics.

F.3.2 Climatological Data Requirements

The Ministry's GAS model requires input climatological data from both hourly observing stations and upper air stations. There are no locations within the study area for which both hourly observations and upper air data are available. To get the model input required upper data from U.S. and Quebec upper air stations must be matched with data from Ontario hourly observing stations.

The process of selecting locations to be modelled starts with the list of hourly observing stations in Ontario and eliminates those that have similar climatological conditions. Appropriate upper air data are then matched to these remaining locations.

The Ministry's MET and GAS models require hourly air temperature, cloud opacity, wind speed and wind direction observations in addition to a daily snow on the ground indicator and mixing height, which is derived from upper air temperature profiles. Thus the starting point for the selection of locations is the 32 hourly observing stations in Ontario in the climatological archive of Environment Canada, Atmospheric Environment Service. Most of these stations have a data record extending for approximately 30 years. This is the typical period of record considered necessary for a useful climatological data set.

One year is composed of 8760 hours, so the analysis of four hourly weather elements for a 30 year period for all Ontario stations would require analysis of over 30 million observations. This was well beyond the scope of the project.

F.3.3 Approach to the Selection of Locations

To reduce the number of locations, and hence the computational work load, in a scientifically credible manner it is necessary to develop criteria to determine when stations have similar climatological characteristics from the perspective of the dispersion model.

An examination of the Ontario Ministry of the Environment's model indicated that the development of dispersion contours around a source depends heavily on the wind speed and direction of the source area. Accordingly, we began by comparing mean annual statistics of wind speed and direction for the 32 available stations.

Several stations are located very close to one another, and so allow us to define criteria for similar climatological characteristics. For example, Toronto Downsview Airport (latitude $43^{\circ} 45'$ N, longitude $79^{\circ} 29'$ W) or Toronto International Airport (latitude $43^{\circ} 40'$ N, longitude $79^{\circ} 38'$ W) could be used to represent conditions in the Toronto area. Similarly, either Ottawa Rockcliffe Airport (latitude $45^{\circ} 27'$, longitude $75^{\circ} 38'$ W) or Ottawa International Airport (latitude $45^{\circ} 19'$ N, longitude $75^{\circ} 40'$ W) could be used to represent conditions in the Ottawa area. It follows that if other geographically proximate stations had wind statistics as similar to one another as these station pairs, then they too could be considered interchangeable for the purposes of this study.

F.3.4 Wind Speed and Direction Comparisons

Stations were first compared by examining the average annual frequency of occurrence of each wind direction (8 point compass) and calm conditions. Each of these nine values for one station in a station pair was subtracted from the corresponding value for the other station to obtain their difference. The largest difference across these nine values was then selected to represent the maximum departure of each station from the other in terms of wind direction frequency. For the two Toronto stations, the largest difference occurred for northerly winds which are observed 17 per cent of the time at the International Airport as opposed to 11.7 per cent of the time at the Downsview Airport for a difference of 5.3 per cent (Environment Canada, 1982). The corresponding value for the two Ottawa stations was 3.4 per cent. These values are given in Exhibit F.1 along with similar values for all possible station pairs in Ontario.

Wind speed characteristics were compared by examining average annual wind speed values by direction (8 point compass). Again the largest difference among the eight wind speeds was selected to represent the maximum departure of each station from the other for each station pair. These values are given in Exhibit F.2 for all Ontario station pairs. For the two Toronto stations the maximum wind speed difference was 2.7 km/h, while the corresponding value for the Ottawa stations was 3.4 km/h.

F.3.5 Selection Criteria

From these examples we concluded that stations could be considered to be essentially similar for dispersion modelling purposes if their maximum wind direction difference was less than 5 per cent and if their maximum wind speed difference was less than 3 km/h. This rule is, if anything, too stringent since

EXHIBIT E - 1

WIND DIRECTION

Maximum Difference for the 8-Point Compass Plus Calm (χ Frequency)

WIND SPEED

Maximum Difference for the 8-Point Compass in km/hr.

neither the Toronto stations nor the Ottawa stations would qualify as essentially similar according to our criteria.

F.3.6 Selection of Locations

Four geographical areas were found to contain "essentially similar" stations that met or almost met the similarity criteria defined above. These areas included northwestern Ontario, northeastern Ontario, Georgian Bay and southwestern Ontario. Plots of average annual wind direction occurrence and average annual wind speed by direction for the candidate stations in these regions are given these regions in Exhibit F.3 through F.6, respectively. The two stations in Georgian Bay and Southwestern Ontario obeyed the similarity rule completely.

In northeastern Ontario, Timmins Airport and Kapuskasing Airport were essentially similar according to the rule while the Timmins Airport/Earlton Airport pair (5.3 per cent and 4.12 km/h) and the Earlton Airport/Kapuskasing Airport pair (3.8 per cent and 3.21 km/h) did not. In northwestern Ontario, Armstrong Airport was the station most closely approximating the four others in this group, but only the Armstrong Airport/Sioux Lookout pair were essential similar according to our selection rule.

Despite the fact that some northeastern stations and most northwestern stations had differences larger than was specified by the criteria of essential similarity, these stations are located in regions with very few establishments in the economic sectors being studied. Hence the use of additional dispersion patterns in those regions was not justified, despite the slightly larger dissimilarities.

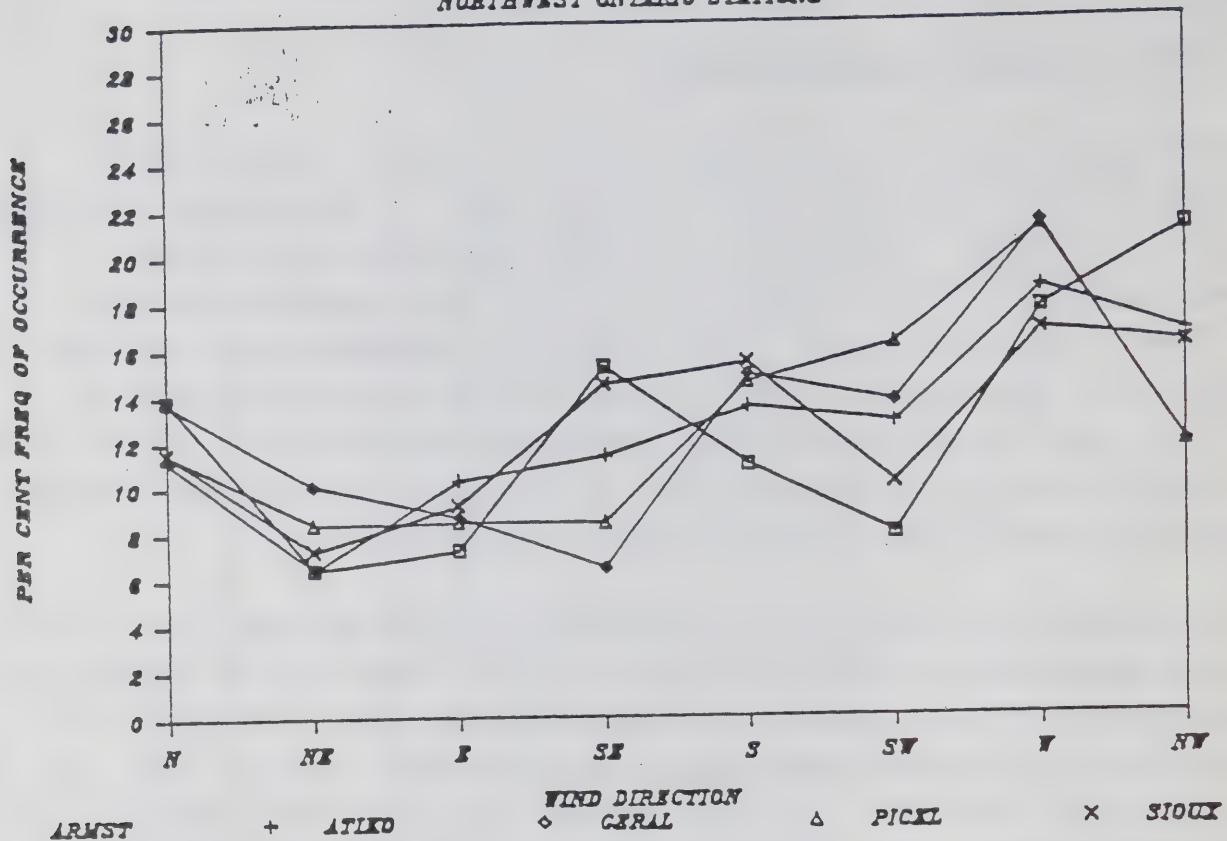
The amalgamations adopted based on the procedures described above are as follows: (the representative station is underlined); Toronto (Toronto International Airport, Toronto Downsview

F - 10

EXHIBIT F - 3

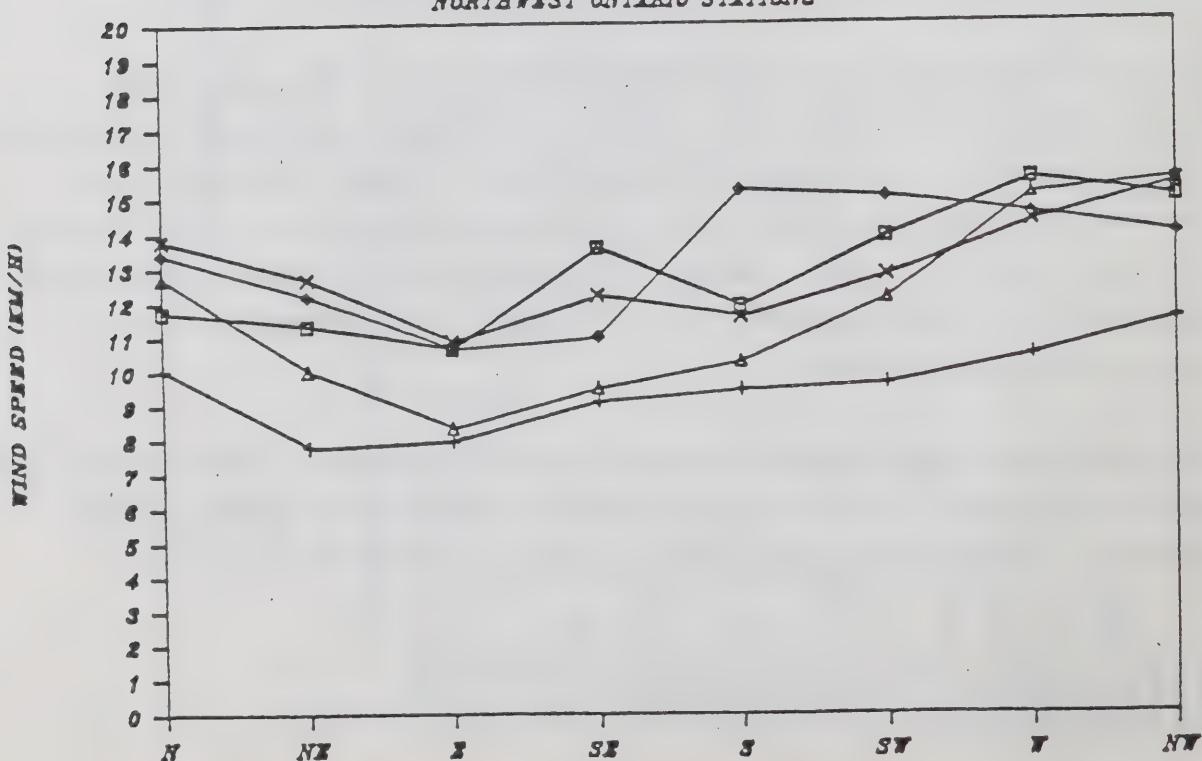
Wind Correlations-Northwestern Ontario

WIND DIRECTION OCCURRENCE
NORTHWEST ONTARIO STATIONS



AVG WIND SPEED BY DIRECTION

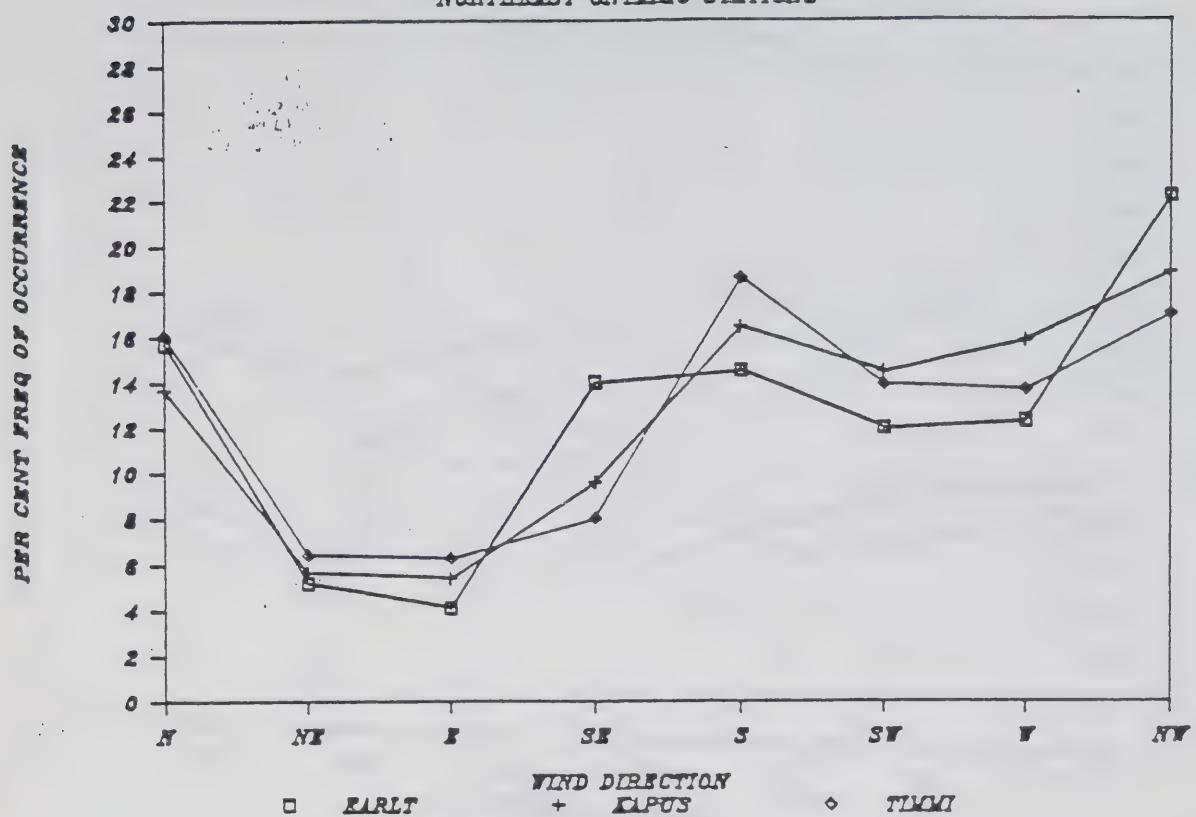
NORTHWEST ONTARIO STATIONS



Wind Correlations-Northeastern Ontario

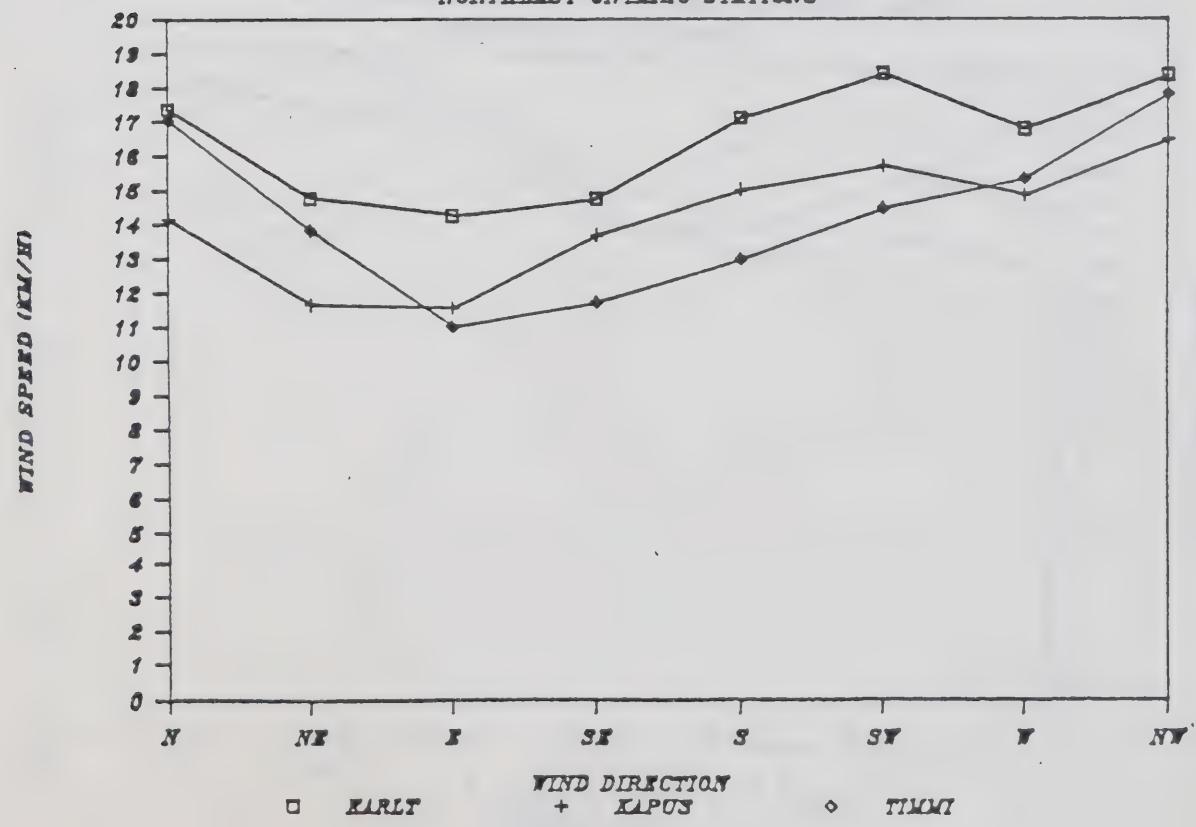
WIND DIRECTION OCCURRENCE

NORTHEAST ONTARIO STATIONS



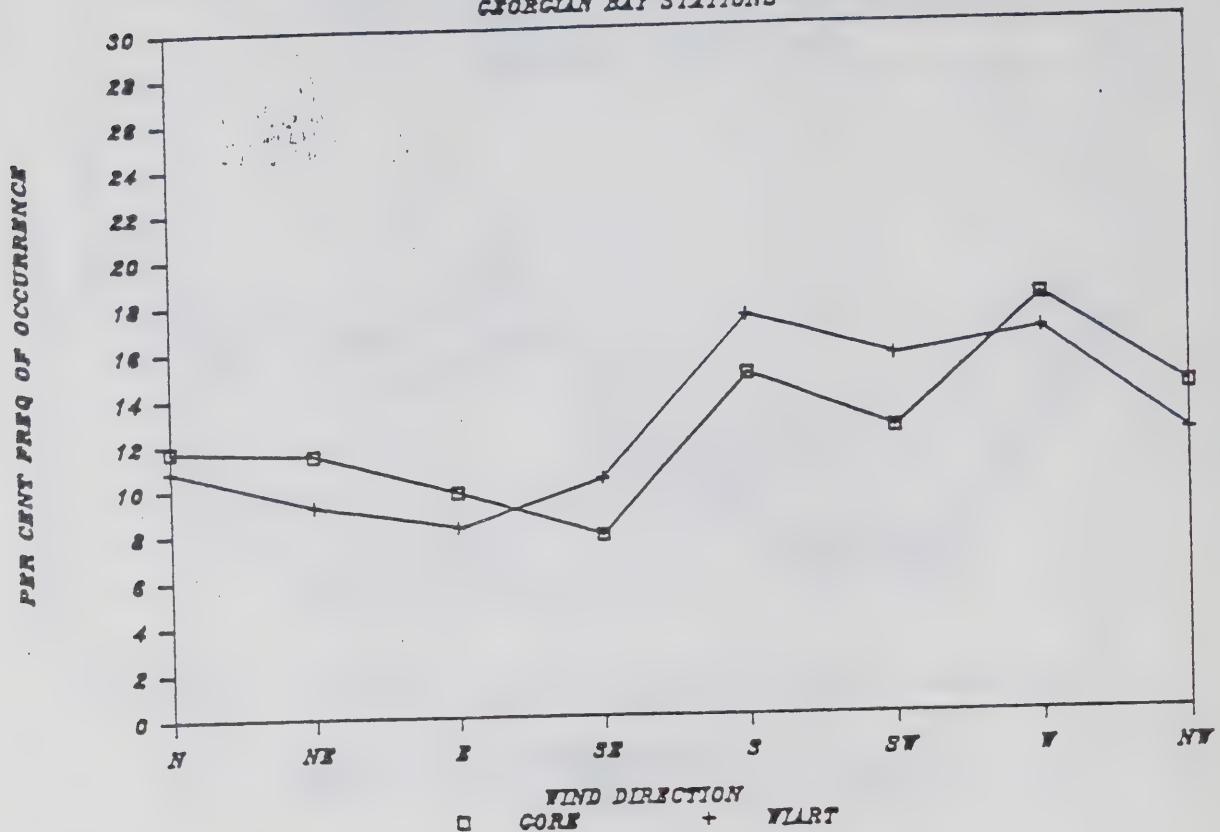
AVG WIND SPEED BY DIRECTION

NORTHEAST ONTARIO STATIONS

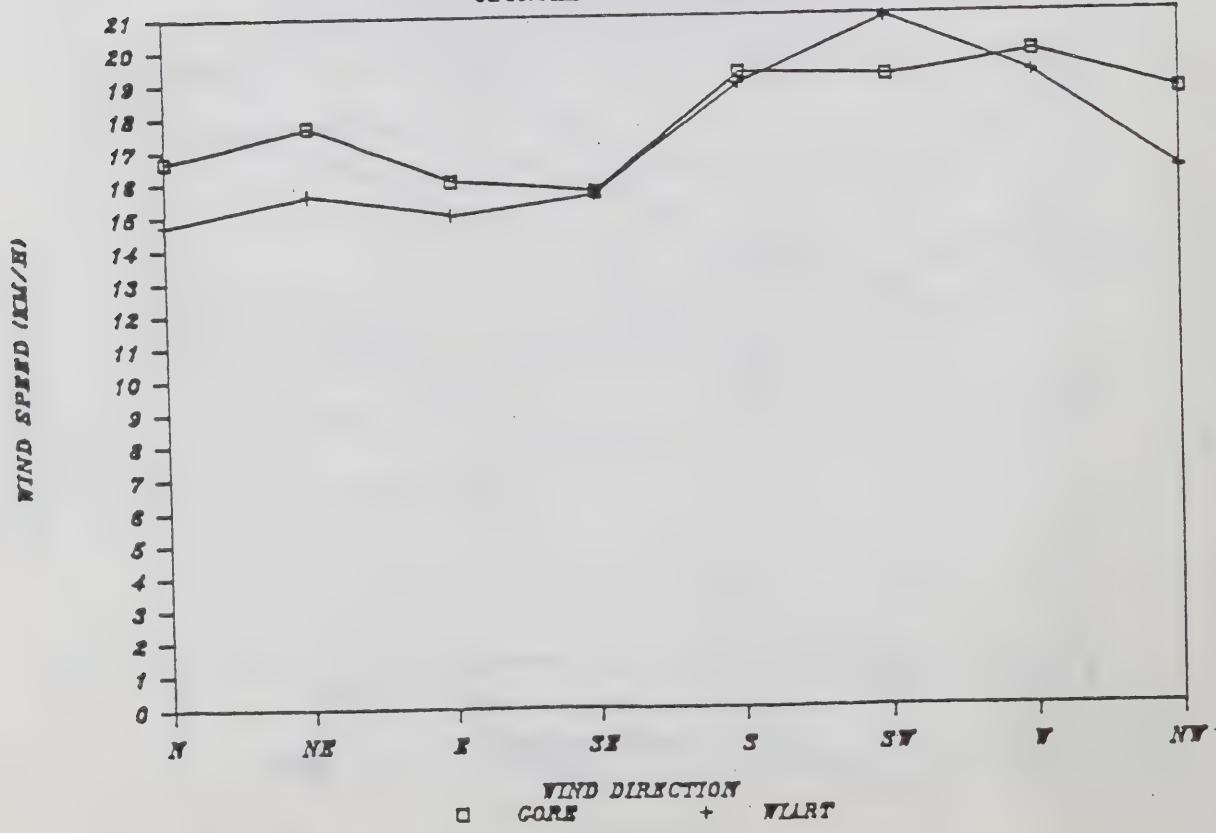


Wind Correlations-Georgian Bay

WIND DIRECTION OCCURRENCE GEORGIAN BAY STATIONS

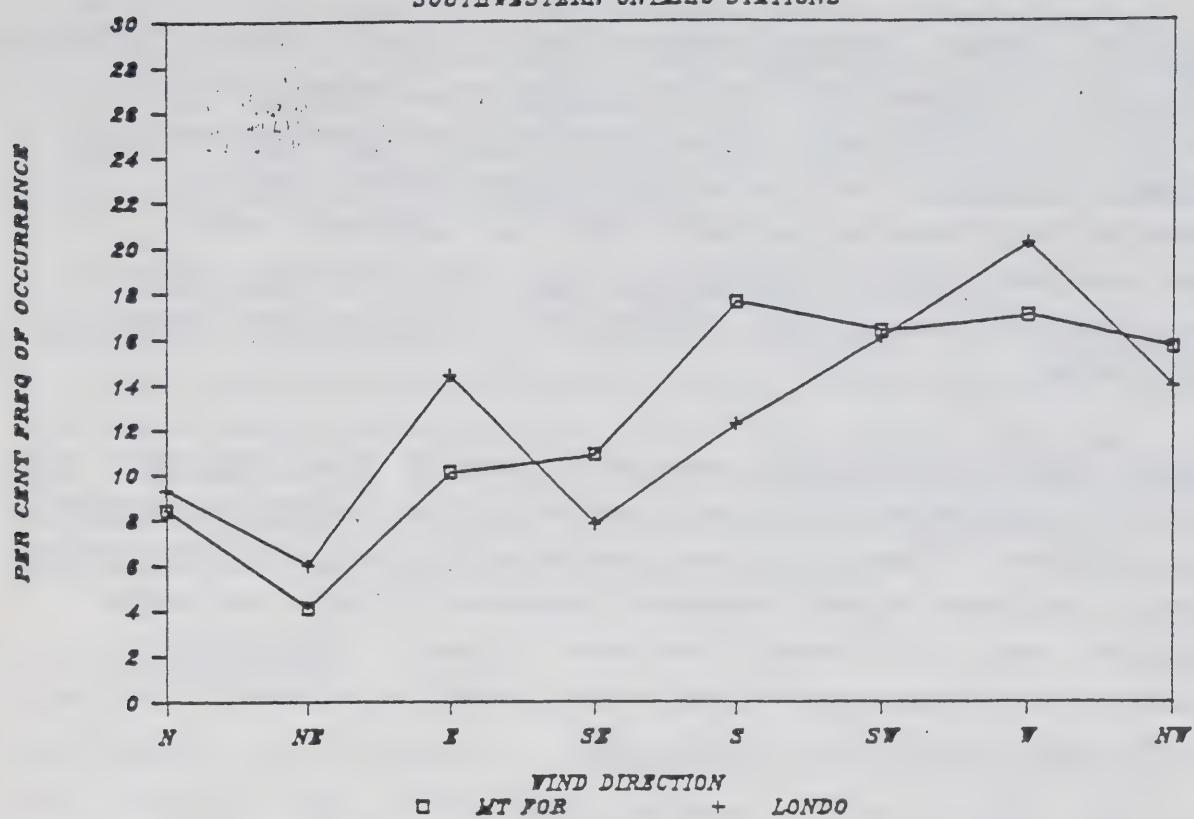


AVG WIND SPEED BY DIRECTION GEORGIAN BAY STATIONS

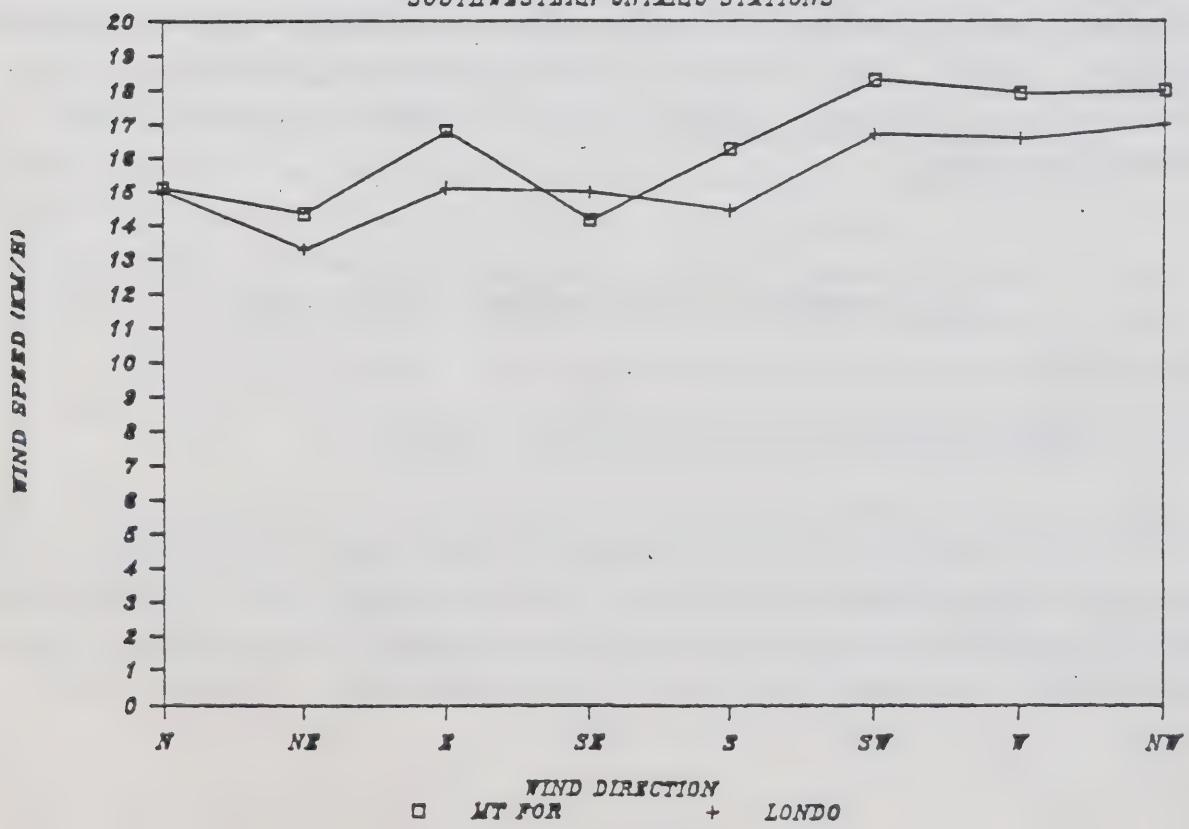


Wind Correlations-Southwestern Ontario

WIND DIRECTION OCCURRENCE SOUTHWESTERN ONTARIO STATIONS



AVG WIND SPEED BY DIRECTION SOUTHWESTERN ONTARIO STATIONS



Airport), Ottawa (Ottawa International Airport, Ottawa Rockcliffe Airport), Northwestern Ontario (Armstrong Airport, Atikokan, Geraldton, Pickle Lake, Sioux Lookout), Northeastern Ontario (Timmins Airport, Earlton Airport, Kapuskasing Airport), Georgian Bay (Wiarton Airport, Gore Bay Airport), and Southwestern Ontario (London Airport, Mount Forest). These amalgamations resulted in the removal of 10 stations from the data base.

Eight additional stations were also removed since they are not in areas with significant sources of the contaminants studied in this project. These stations are Armstrong Airport, Big Trout Lake, Lansdowne House, Moosonee, Muskoka Airport, Petawawa Airport, Red Lake Airport, and Wawa Airport. Any sources examined in these regions use more distant stations to define average meteorological conditions.

The stations retained, which together are taken to define the meteorological conditions for the province, are Kenora Airport, Kingston Airport, London Airport, North Bay Airport, Ottawa International Airport, Sault Ste. Marie Airport, Simcoe, Sudbury Airport, Thunder Bay Airport, Timmins Airport, Toronto International Airport, Trenton Airport, Wiarton Airport and Windsor Airport.

F.4 COMPIILATION OF METEOROLOGICAL DATA

F.4.1 Need to Select a Representative Year

While the rationalization of observing stations to be included in the analysis reduced the data to be analyzed by more than 50 per cent, the data burden was still too large for the project. To accomplish a further reduction it was decided to replace the

30 year period of record used to characterize meteorological conditions with a representative year that closely approximates the 30 year period. This representative year yields an annual dispersion field very close to that obtained from the 30 year history for each of the 14 stations.

For the purposes of the project only annual statistics summarizing the dispersion pattern are required, the large number of hourly observations in one year ensure that statistics derived from these hourly observations do not vary greatly from year to year. Consequently, any year in the data base could be used to represent typical conditions if all input data were hourly observations. Such, however, is not the case.

F.4.2 Snow Cover

Specifically the presence or absence of snow on the ground is not subject to the law of large numbers in the way that hourly observations are. The period of time that snow is present for any station varies a great deal from year to year. In the Ministry's model the presence of snow on the ground is assumed to reflect all short wave radiation back into space, with the result that convective conditions cannot occur (Ontario Ministry of the Environment, 1987). The disallowance of convective conditions for an unusually long or unusually short period relative to the 30 year average may well result in a significantly different dispersion field. Accordingly, it was decided to seek a single year which, for all 14 stations, the winter snow cover period was as close as possible to the average obtained using the entire period of record for the station.

The time period for which snow was on the ground for at least seven consecutive days was determined for each of the 14 stations for all years of each stations's climatological record. Significant year to year variability was found. For example, in

Kenora a 30 year data base indicated that on average seven consecutive days of snow cover began on November 11 and ended on April 11 for a total of 152 days. However, in 1968 snow was present for only 126 days while in 1965 snow was present for 179 days. Other stations showed similar variability in terms of the length of the snow cover season.

F.4.3 Selection of the Representative Year

Only one year, 1986, had the time with snow on the ground within one standard deviation of the long term average for all 14 stations. Thus 1986 was selected as the representative year for the calculation of average annual dispersion statistics.

F.4.4 Compilation of Climatological Input Data: Hourly Station Data

Hourly meteorological observations for the representative year for each of the 14 centres (totalling 500,000 observations) were purchased from the Canadian Climate Centre, Atmospheric Environment Service and formatted for input to the Ministry's METCO program.

The METCO program, provided by the Ministry, allows the use of data formatted for use in the single source GAS model in the newer multi-source, multi-receptor version of the model. The program also allows disabling of upper air wind speeds where desirable.

This program was used as the basis for a general conversion program (METCOR) written by the study group to automate the interface of Environment Canada Surface Data, U.S. and Canadian Upper Air Data, the snow record, data decision-making, flagging and reformatting of input data. The METCOR program produced 14 complete records for the representative year, ready for input

to the Ministry's MET program (meteorological parameter calculation program). These 14 records represent average meteorological conditions for the Province of Ontario for the period 1957 to 1986 inclusive. The MET program generates the meteorological parameters required as input by the dispersion (GAS) model.

F.4.5 GMT Conversion

Canadian surface weather data are recorded in local standard time for each station. A program segment was written to convert local standard time (date) to Greenwich Mean Time (GMT) for input to the GAS model.

F.4.6 Cloud Cover

Canadian surface weather data expresses cloud cover and cloud opacity in 10ths. Cloud cover and cloud opacity affect the occurrence of convective conditions. Cloud opacity, where available, is the better determinator of convective conditions and was used in this study. A program segment was used to convert from 10ths to 8ths for input to the GAS model.

F.4.7 The Snow Record

The most significant determinants of convective conditions are the presence or absence of snow cover and the presence or absence of daylight. Most winters are characterized by alternating periods of "snow-on" and "snow-off". Wide swings occur, throughout the 30-year record, of starting and ending dates - dates of snow cover, and dates of bare ground. The snow cover period may also be interrupted by periods of bare ground.

The 30-year record for each centre was reduced to a mean start and end date of snow cover. The definition of snow cover used is

the period from which persistent (7-day duration), 2 cm snow cover was first recorded to its last recorded date. This definition had the effect of reducing the length of the snow season. The reduction in the length of the season offsets, to some degree, the increase in the number of "snow-on" days which result from calling the snow cover period "continuous".

The 30-year mean period was used as the "snow-on" period for the representative year. A program segment was written to automate snow cover distribution in the model.

F.4.8 Wind

Canadian surface wind speed is in units of km/hr. A program segment was written to convert this to m/sec for the GAS model. Calm conditions were assigned a wind speed value of 0 m/sec where no value was provided. The MET and GAS modules increase this to a 1.5 m/sec minimum in appropriate cases. Upper air wind speeds were disabled in the model.

F.4.9 Wind Direction

The representative year chosen, being recent, was available in 10 degree compass resolution and was thus compatible with the GAS model interpolation routine (wind direction ± 5 degree randomization). A program segment was written to multiply the AES compass (0 to 36) by 10. In Environment Canada format, 36 is North and 0 is calm. A program segment was written to reassign 36 to 0 for the GAS model. Initial 0 (calm) values were assigned the first previous non-calm wind direction.

F.4.10 Upper Air Data

No Canadian upper air stations exist in proximity to most

Ontario emission centres. Thus, it was necessary to obtain U.S. near-border data to use with Ontario surface data.

F.4.11 Mixing Heights: U.S. Locations

Mixing heights were purchased for the representative year from the U.S. National Climatic Data Centre in North Carolina. The U.S. computer program used, generates a.m. and p.m. mixing heights using upper air soundings combined with surface data for the same station (Doty, 1983). The normal U.S. practice is to combine surface data from the surface location of interest. However, since the surface locations of interest are all Canadian centres, this was not possible. The use of matching upper air/surface data for the same station was considered a reasonable compromise.

Twice daily, mixing heights for the entire year were obtained for Flint, Michigan; Sault Ste. Marie, Michigan; International Falls, Minnesota; and Buffalo, New York.

F.4.12 Mixing Heights: Canadian Locations

Since mixing heights cannot be purchased from Environment Canada for Canadian Upper Air Stations, raw soundings data were purchased. The only Canadian centre in proximity to the locations to be modelled is Maniwaki, Quebec.

Since Maniwaki, Quebec surface data were not purchased, Ottawa surface data were used with the Maniwaki upper air data to generate mixing heights. This is in accordance with U.S. practice. A program was written to adjust base temperatures for base elevations, determine maximum surface temperatures for each period, and calculate the elevation of intersection between the sounding temperature profile and the dry adiabatic lapse curve for each surface temperature maximum.

A linear interpolation routine was written to refine intersections which occurred between sounding elevations. Negative elevations were assigned a value of zero, which was flagged by the revised MET program for cases which would ordinarily be convective. In such cases, a zero mixing height resulted in an invalid MET case in the GAS model execution (i.e., no calculation).

Ottawa was chosen as the surface centre because it is geographically central to the area of Ontario for which Maniwaki, Quebec upper air data would be deemed representative (i.e., Timmins, North Bay, Ottawa, Kingston). Time and budget did not permit a centre-by-centre match of local surface and Maniwaki upper air data.

F.4.13 Missing Data Flags

In the case of missing meteorological data a flag value of IDATA = 999 was assigned. This generates an invalid MET case for the GAS run (i.e., no calculation for that case).

F.4.14 Negative or Missing Mixing Height Flags

In cases of negative or missing mixing heights, IDATA was assigned a value of 987. A short addition to the MET program was written such that if IDATA = 987 and meteorological conditions were convective, IFLAG would be assigned a value of 999 (an invalid case).

F.4.15 Limitations of the Meteorological Database

Some centres, despite catalogue indications, were found to have incomplete meteorological records. For example, in Simcoe, measurements were only available for weekday periods. Results of

modelling with such data are less reliable than results for more detailed input.

The use of Upper Air Data from geographically removed centres is a somewhat dubious procedure. However it is one that is without alternative since upper air stations are so rare. For example, using Buffalo upper air data for Toronto leads to questions of how representative upper air data for a centre on the east end of a lake is of another centre on the north shore of a different lake. Errors would occur only in the case of convective conditions and are estimated to yield an output variance, on an annual average, of no more than 5 to 10 per cent. The best centre, by this criterion, is Sault Ste. Marie, Ontario, since the Sault Ste. Marie, Michigan upper air station is so close to the Canadian surface weather station.

There are many surface stations in northwestern Ontario. Kenora was chosen to represent this area based on its population density. It is estimated that this choice would affect the dispersion of pollutants in other centres (e.g., Armstrong) to a smaller degree (5 to 10 per cent). It was not expected that large concentration excursions would occur and none were observed.

The dispersion model (GAS) does not deal with calm conditions "as are" but rather increases wind speed to 1.5 m/sec. for applicable cases. In addition, Environment Canada merely flags wind direction in calm cases (since by definition of calm, there is no wind to have a direction). To mesh what the model does, with what the source data doesn't provide, a wind direction was assigned in each case of calm. The choice of direction was that of the first previous "non-calm" wind direction. This perturbs the short term wind direction statistic less than introduction of an artificial randomization function. The frequency of occurrence of calm conditions is estimated at less than

2 per cent, so the impact of this assumption on results considered to be small.

F.5 EMISSION SOURCE CHARACTERISTICS

The GAS model requires, in addition to climatological data, input with respect to emission source characteristics. The characteristics of the several thousand emissions sources are, with very rare exceptions, not known. Hence these characteristics must be estimated. Since each of the 14 dispersion patterns could be applied to several hundred sources, the estimated characteristics should be typical of the variety of industrial establishments emitting the contaminants.

F.5.1 Building Sources

Of the several thousand commercial emissions sources in Ontario subject to the proposed revisions to Regulation 308, by far the most numerous are building sources. Such sources are generally defined as sources from which fugitive emissions emanate or stack emissions emerge at elevations less than twice the height of the building.

To precisely model emissions from such sources the exact dimensions of the building and the stack must be known. In cases of complex building shape (i.e., non-rectangular) or complex vicinity (i.e., larger buildings or variable terrain) mathematical modelling is inappropriate and physical modelling is preferred. Physical modelling is not possible for this analysis. Hence it is necessary to assume that all buildings are isolated, rectangular buildings with a stack less than twice the height of the building.

For this study, no information was available on building or building-stack dimensions for any source. To estimate ambient concentration, each source was assumed to be a building of 7 m height and 100 m width with a stack of less than 14 m elevation, emitting pollutants at 0 velocity and at ambient exit temperature. Such a building is a typical "industrial park" source. This assumption leads to very high ambient concentration uncertainties (i.e., order of magnitude) within 500 m of the source for source buildings of other configuration but is a far better source assumption than a zero elevation emitter. Reasonable concentration estimates beyond 500 m are achieved.

Since no data were available on individual elevated and buoyant (exit temperature above the ambient temperature) elevated source characteristics, such sources have been represented as building sources. The limitations of this approach are discussed in the next section.

F.5.2 Implications of the Assumed Building Source Characteristics

If an emission is ground-based, the building source assumption will yield artificially high initial dilution within 500 m of the origin. If an emission is elevated, and possibly buoyant, the building source assumption will yield artificially high concentrations within 500 m of the source. If the source is less than about 30 m in elevation and of moderate buoyancy, beyond 500 m concentrations will generally fall within the same order of magnitude with the highest discrepancies found at the perimeter (near the zero concentration area). In general, the higher and hotter the source, the larger the discrepancies.

Distribution inaccuracies resulting from the assumptions can be illustrated by the fact that the worst case meteorology for an

elevated source occurs under convective atmospheric conditions, whereas the worst case meteorology for a building source occurs under stable atmospheric conditions. This type of possible inaccuracy contributed to the decision to use concentration averages of 8,760 hourly meteorological cases rather than averages over shorter time frames. Where sources approached the characteristics of the "typical building source" the accuracy of the annual average would be unassailable. In other cases, the annual average would have a "smoothing" effect where periods of larger differences would be offset to some degree by periods of smaller differences yielding a better estimate of average concentration. This minimizes the limitations of these source assumptions.

F.5.3 Elevated Sources

Elevated sources, by definition, emit beyond twice the elevation of the highest part of an attached or adjacent building. Depending on the stack exit temperature the emission plume may be more or less buoyant than the surrounding air. Accurate modelling requires that all of the stack parameters be known. These parameters are: stack height, exit diameter, exit velocity, exit temperature (and emission rate).

Such information was not collected for any source in Ontario as part of this study. In addition, the use the proposed new Ontario models entirely precluded use of individual source information of any kind. If one took 2,000 sources for example, and ran one years' meteorology, using an IBM-AT with math-coprocessor, 36,000 hours of computer time would have been required (i.e., 4.1 years).

F.5.4 Near-Lake Sources

Discussions with Ministry staff led to consideration that lakeshore effects should be dealt with in modelling certain sources.

Predominant sources to which lakeshore effects would most often be encountered were identified as Lakeview Generating Station in Mississauga, and Nanticoke Generating Station. The present development version of the Ministry's proposed Lakeshore Model has not been integrated with the general GAS model. Such integration is necessary because a lakeshore effect can only occur under specific conditions which will only arise at certain times during the year. At other times dispersion would occur as per the GAS model.

We endeavoured to perform the model integration; however, the project budget was exceeded as a result and this work remains incomplete. Hence, lakeshore effects are not included in the output of this study.

The error involved in ignoring lakeshore effects for these two sources would be an under-estimation in the range of 1 to 3 times of annual average concentrations within 3 km onshore from these two sources.

F.6 THE RECEPTOR GRID

The Ministry's grid-generator program RECGEN was used to generate a receptor grid network from 0 to 24 km of 2 km resolution. A finer grid of 500 m and 1,000 m grid points was superimposed on

the coarse grid to permit better resolution in the near-source area where most of the impact of building sources is felt.

The GAS model calculated running average (annual average in this study) concentrations for each receptor point (grid coordinate). A surface roughness of 1.0 m and a receptor elevation of 0.0 m was used in all cases.

Due to the assumptions relating to source characteristics the resulting ambient concentrations within 500 m are most uncertain. As an approximation, where receptor grids intersect/overlap (for different sources), if the source is known to be elevated the within-500 m area could be taken to be of zero concentration. Where the source was not known to be elevated, the within-500 m area could be taken to be of concentration equal to that at the 500 m boundary. The alternative would be to ignore all areas of overlap within 500 m of the source (which in the case of Toronto might mean ignoring most of the city for some pollutants).

Fourteen dispersion patterns were generated; one for each location selected. The source characteristics are assumed to be the same for all 14 patterns. An emission rate of 1 gram/sec is used in each case. Since the model is linear with respect to dispersion, the calculated concentration at each grid coordinate is scaled by the emission rate for the specific source. For example, if the concentration at twelve kilometers due east of the source is calculated by the model to be 0.0158 micrograms/cu.m. and a given source emits a contaminant at a rate of 5 grams/sec then the ambient concentration twelve km due east of that source will be 0.0790 micrograms/cu.m.

F.7 QUALITY ASSURANCE

F.7.1 Input Quality Control

Considerable processing, conversion, and flagging of data were required prior to running the dispersion model. Conversion, processing, and flagging programs were all validated manually using Toronto and Simcoe meteorological data. MET program output (GAS program input) was reviewed in detail (i.e., for the entire one year hourly record) prior to GAS program execution. Byte volumes of records for other centres were compared for consistency and random hourly records were inspected for other centres.

All centres used the same input files, except for meteorological data where individual centre files were used. To maintain file control, all non-.MET files (i.e., .RUN, .FUN, .REC, .SRC and blank .AVG files) were located in a write-protected directory. A DOS batch-program was written which transferred these files (renamed) to the execution directory, prompted for the correct .MET file, verified the presence of these files, and executed the GAS model program.

F.7.2 Output Quality Control

The number of valid and invalid (uncalculated) MET cases was inspected on completion of each run and compared with the prior knowledge of the relative occurrence of missing and flagging data. Exhibit F.7, the Run Record, illustrates this.

All output (.AVG) files were imported to a LOTUS Symphony file, compressed, and compared. The coordinates of the maximum concentration receptor were inspected in each case.

THE RUN RECORD

Name of Centre	Filename	Upper Air Station	Hours Difference from GHT	Snow **	No. of Valid HBT Cases	No. of Invalid HBT Cases	No. of MET Cases
			Start	End			
Kingston	KIN	Maniwaki, Qué.	5	12-19	03-17	5736	3024
Kenora	KEN	Int'l. Falls, MN	6	11-11	04-11	8714	46
London	LON	Flint, MI	5	12-10	03-11	8609	151
North Bay	NOR	Maniwaki, Qué.	5	11-21	04-13	8709	51
Ottawa	OTT	Maniwaki, Qué.	5	12-02	03-31	8405	355
Simcoe	SIH	Buffalo, NY	5	12-15	03-08	6662	2002
Sault Ste. Marie	SOO	Sault Ste. Marie, MI	5	11-24	04-06	8630	130
Sudbury	SUD	Sault Ste. Marie, MI	5	11-22	04-09	8631	129
Sudbury, Inco*	SUDINCO	Sault Ste. Marie, MI	5	11-22	04-09	8631	129
Thunder Bay	THU	Int'l. Falls, MN	5	11-25	04-02	8700	60
Timmins	TIM	Maniwaki, Qué.	5	11-12	04-23	8736	24
Toronto	TOR	Buffalo, NY	5	12-15	03-11	8656	104
Trenton	TRE	Buffalo, NY	5	12-17	03-15	8662	98
Wlarton	WIA	Flint, MI	5	12-03	03-28	8585	175
Windsor	WIN	Flint, MI	5	12-28	02-16	8590	168

*Elevated Source, all others are Building Sources.

**30-year average dates for persistent (2cm, 7-day), snow cover.

The relative concentrations of the maxima were compared. With each centre using the same building source and unit emission rate, the maxima should be within the same order of magnitude. In addition the concentrations at every grid point were summed for each centre and the sums compared between centres. This test on distribution should also yield results in the same order of magnitude.

All of the above tests were passed. Exhibit F.8 presents the first page of this summary file as an example.

A DOS batch program was written to copy the appropriate files to diskette for back-up and to save output files to the appropriate directory. The DOS programs ensured that file integrity was maintained during movement and handling.

F.8 REFERENCES

Doty, Stephen R., 1983. Climatological Aids in Determining Air Pollution Potential, U.S. National Climatic Centre. 26 pp.

Environment Canada, Atmospheric Environment Service, 1981. Climatological Station Data Catalogue, Ontario. 125 pp.

Environment Canada, Atmospheric Environment Service, 1982. Canadian Climate Normals, Volume 5: Wind. 1951-1980. 283 pp.

Ontario Ministry of the Environment, 1987. Air Pollution Regulation 308, Appendix H: Air Pollution - General Regulation Modelling Proposals. 170 pp.

EXHIBIT F - 8

ONTARIO AMBIENT CONCENTRATIONS - Annual Averages from Proposed RKG.308 Model

		MON	TUE	WED	THU	FRI	SAT	SUNDAY	MON	TUE	WED	THU	FRI	SAT	SUNDAY	MON	TUE	WED	THU	FRI	SAT	SUNDAY
MAXIMUM CONC:	6.407	5.741	3.430	10.459	7.039	0.00044	11.232	6.496	6.431	0.051	4.266	6.837	6.195	4.197	13.376							
SUM OF GRIDS:	51.493	50.134	21.710	58.676	56.524	0.13708	56.513	40.570	60.709	65.652	40.178	53.091	59.257	31.764	66.047							
I	I																					
-1000	-1000	0.657	0.378	0.210	0.565	0.622	0.00012	0.558	0.211	0.708	0.852	0.596	0.414	0.458	0.583	0.474						
-500	-1000	1.115	0.601	0.227	0.906	0.724	0.00009	0.919	0.472	1.863	0.996	0.392	0.743	0.825	0.705	1.026						
0	-1000	1.991	1.739	0.592	1.150	1.319	0.00007	0.787	0.900	1.247	2.021	0.916	0.821	1.590	0.741	2.266						
500	-1000	1.250	0.962	0.315	1.224	1.297	0.00007	0.421	1.593	2.170	0.898	0.465	0.572	1.103	1.012	1.346						
1000	-1000	0.412	0.431	0.390	0.904	1.007	0.00012	0.567	0.623	0.452	0.773	0.206	0.437	0.921	0.301	1.215						
-1000	-500	0.618	0.777	0.293	1.580	0.439	0.00007	0.906	0.198	0.884	0.605	0.619	0.952	0.777	0.317	0.643						
-500	-500	2.143	1.093	0.779	1.896	2.033	0.00004	1.934	0.736	2.503	2.775	2.063	1.445	1.594	2.051	1.594						
0	-500	6.407	5.424	1.862	3.732	4.399	0.00002	2.607	3.104	4.275	6.211	2.961	5.232	5.232	2.602	7.058						
500	-500	2.793	1.523	1.425	3.165	3.364	0.00004	1.916	2.131	2.817	2.539	0.723	1.512	3.086	1.100	4.063						
1000	-500	1.116	1.011	0.501	1.719	1.884	0.00009	1.190	1.137	1.236	1.083	0.360	1.335	1.500	0.492	1.711						
1000	0	0.599	1.524	3.155	0.412	0.00003	0.951	0.268	0.586	1.069	0.878	0.598	1.106	0.116	1.659							
-1000	0	1.991	5.025	1.200	10.459	1.690	0.00001	3.339	1.011	1.944	3.772	2.873	2.245	3.767	0.451	5.156						
-500	0	0	0	0	0	0	0.0000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	
0	0	4.109	5.741	3.430	7.309	7.039	0.00002	11.232	6.496	6.431	0.961	2.631	5.077	6.195	4.197	8.293						
500	0	1.781	1.712	0.995	1.040	2.405	0.00009	3.470	1.946	2.023	2.523	0.736	1.474	1.929	1.201	2.559						
1000	500	0.614	1.183	0.014	1.365	0.421	0.00002	0.385	0.398	0.173	0.967	0.933	0.490	0.075	0.153	1.346						
-1000	500	1.346	1.010	0.445	2.220	1.111	0.00001	0.308	1.211	0.801	2.353	1.801	1.164	2.004	0.697	1.765						
-500	500	4.416	3.463	1.429	2.736	3.677	0.00001	1.790	3.932	5.018	6.191	4.266	6.037	4.006	3.413	13.376						
0	500	2.016	1.401	0.669	1.586	4.803	0.00004	4.934	1.584	4.428	2.065	2.816	4.201	3.406	1.566	3.189						
500	500	1.045	1.104	0.343	0.940	2.025	0.00011	3.243	1.165	1.530	1.577	0.972	2.165	2.035	0.828	1.927						
1000	1000	0.400	0.534	0.143	0.642	0.311	0.00003	0.081	0.338	0.249	0.712	0.535	0.342	0.556	0.200	0.534						
-1000	1000	1.016	0.820	0.156	0.534	0.681	0.00003	0.243	0.718	0.436	1.063	0.915	0.784	0.838	0.691	0.994						
-500	1000	0.004	0.002	0.002	0.002	0.003	0.00017	0.002	0.001	0.001	0.002	0.001	0.004	0.002	0.002	0.001	0.003	0.002	0.002	0.003		
0	1000	1.257	1.015	0.397	0.881	1.107	0.00005	0.522	1.202	1.032	1.913	1.190	2.094	1.239	0.927							
500	1000	1.477	0.682	0.204	0.456	1.485	0.00009	1.070	0.620	1.546	0.941	1.492	2.803	1.208	0.466							
1000	1000	0.588	0.390	0.170	0.464	1.467	0.00014	1.486	0.451	1.335	0.582	0.812	1.242	1.016	0.427	0.939						
-1000	1000	0.006	0.003	0.002	0.004	0.004	0.00020	0.005	0.002	0.005	0.009	0.006	0.003	0.002	0.005	0.004	0.003	0.004	0.003	0.003		
-2000	0	0.004	0.002	0.003	0.004	0.005	0.00011	0.004	0.001	0.004	0.007	0.003	0.001	0.003	0.002	0.003	0.002	0.003	0.002	0.003		
-2000	0	0.004	0.003	0.002	0.003	0.002	0.00019	0.005	0.001	0.006	0.004	0.005	0.004	0.001	0.003	0.002	0.003	0.002	0.003	0.002		
-2000	0	0.004	0.003	0.002	0.003	0.003	0.00019	0.004	0.001	0.006	0.005	0.004	0.003	0.002	0.003	0.002	0.003	0.002	0.003	0.002		
-18000	-24000	0.006	0.003	0.002	0.004	0.005	0.00020	0.006	0.004	0.006	0.006	0.005	0.011	0.002	0.003	0.004	0.003	0.002	0.003	0.002		
-16000	-24000	0.006	0.004	0.002	0.005	0.006	0.00020	0.007	0.005	0.006	0.006	0.011	0.002	0.003	0.004	0.003	0.002	0.003	0.002	0.003		
-14000	-24000	0.006	0.004	0.002	0.005	0.006	0.00020	0.007	0.005	0.006	0.006	0.011	0.002	0.003	0.004	0.003	0.002	0.003	0.002	0.003		
-12000	-24000	0.006	0.004	0.002	0.005	0.006	0.00020	0.007	0.005	0.006	0.006	0.011	0.002	0.003	0.004	0.003	0.002	0.003	0.002	0.003		

APPENDIX G

Spatial Analysis System

TABLE OF CONTENTS

APPENDIX G

	<u>Page</u>
G.1 INTRODUCTION	G - 1
G.2 WHAT IS SPATIAL ANALYSIS?	G - 1
G.3 GEOGRAPHIC INFORMATION SYSTEMS	G - 2
G.3.1 Data Storage	G - 2
G.3.2 Manipulation Capabilities	G - 3
G.4 USE OF SPANS IN THIS PROJECT	G - 4
G.4.1 Location of Emission Sources	G - 4
G.4.2 Determination of Concentrations	G - 5
G.4.3 Calculation of Ambient Concentration	G - 6
G.4.4 Maps of Environmental Resources at Risk	G - 8
G.4.5 Analysis of Environmental Resources at Risk	G - 9
G.4.6 Analysis of Contaminants for which Ambient Concentrations have been Estimated	G - 9
G.4.7 Analysis of Cases with Exposure-Response and Damage Functions	G - 10

G.1 INTRODUCTION

A vital tool in the analysis of the public benefits of proposed revisions to Regulation 308 used was DPA's spatial analysis system (SPANS). SPANS is a geographic information system. Different geographic information systems specialise in performing different tasks; some work best at creating cartographic maps. SPANS' specialty is analysis and manipulation of spatial data; data which relate to points or areas on maps. It was ideally suited to this assignment which involved locating sources of emissions, the dispersion of those emissions, and identification of the population and environmental resources affected.

This appendix describes some of the features of SPANS and the way it was used in the project.

G.2 WHAT IS SPATIAL ANALYSIS?

Spatial analysis is the ability to investigate the spatial dimension of a problem. Many problems have a spatial dimension. For instance, the analysis of the public benefits of reduced air emissions depend upon where contaminants are deposited and the concentration at each point because that determines the resources affected. Traditionally, the spatial dimensions of problems are addressed by making assumptions (e.g., trade area boundaries) or using manual procedures (map overlays) that limit the number of options considered.

DPA's computerized spatial analysis system allows the spatial components of a problem to be addressed in much more sophisticated and convenient ways. To understand how the spatial analysis system works some background information on geographic information systems is useful.

G.3 GEOGRAPHIC INFORMATION SYSTEMS

Computerized geographic information systems (GIS) are designed to input, store, retrieve, manipulate and display spatial information. They differ primarily in the manner in which they store data and the kind of manipulations they perform best. In turn these capabilities determine the size of computer needed.

G.3.1 Data Storage

A spatial feature has a location, size and shape. The size and shape can range from a point (e.g., a meteorological station) to an irregular area (e.g., a watershed). In addition to these spatial characteristics, the GIS must store a range of attributes associated with the site: average annual temperature, soil type, slope, population, suitability for swimming, etc. Clearly, the data storage demands can quickly become very large, creating a need for larger computers.

The most common approach to accurately specify spatial features is to define their boundaries. A series of line segments are linked to form the boundary of an area. Obviously, the more irregular the area the larger the storage requirements. Some analytical processes, such as map overlays, are very complex with these systems. Line segments must be used to generate the areas, the areas are overlaid, the portions that overlap are determined and a new set of boundary line segments is generated for storage. These systems typically require mini-computers.

The usual approach to minimising storage needs is to pre-define a fixed set of areas. Typically this is a grid (raster) system, although other systems, such as census subdivisions, can be used.

The fixed areas and locations defined by such systems yield major benefits in terms of data storage. The cost is loss of accuracy. Watersheds, slopes, soils, rainfall and many other attributes do not vary according to a fixed grid pattern.

SPANS uses a quadtree structure to store data. This offers a combination of the best features of a boundary-based system and grid system. The quadtree structure divides the total area into progressively smaller quadrants, until a quadrant has uniform characteristics. This results in area units of variable size, so a large area with uniform attributes is stored as such, while much smaller area units are used to accurately define the boundaries of spatial features, such as forest cover, lakes, and built up area. The overall data storage requirements are similar to those for a fixed area system, but the level of accuracy is much greater. The system operates on a micro computer.

G.3.2 Manipulation Capabilities

The manipulation capabilities of a GIS system reflect the needs of users and, to some extent, the data storage techniques employed. The available systems can be broadly defined as cartographic or thematic in orientation. The principal uses of cartographic systems are to record, process revisions to, and prepare updated maps. Although these systems have some analytical capabilities, such as the ability to perform overlays, the emphasis is on cartographic properties such as accuracy, labelling, changes to scale and projection, etc.

Conversely thematic systems emphasize analytical capabilities but at the cost of some cartographic ability such as labelling. SPANS was specifically designed as an analytical system. Its capabilities include:

- . Easy access to a variety of input data;
- . Extensive data manipulation capabilities;
- . Complex overlays of multiple maps;
- . Proximity mapping;
- . Area analysis reports;
- . Use of satellite imagery; and
- . Diverse data display capabilities.

SPANS grew out of needs encountered in the course of DPA's consulting work over the past decade. The system was developed, refined and enhanced over many years and a wide variety of applications.

G.4 USE OF SPANS IN THIS PROJECT

A critical requirement in the calculation of the public benefits of reduced air emissions is the ability to estimate the change in concentration of a given contaminant at any point and to determine the environmental resources that will benefit from this reduced exposure. SPANS provides this capability.

G.4.1 Location of Emission Sources

SPANS is used to locate each emission source. The list of establishments was compiled from the Made in Ontario data base maintained by the Ministry of Industry, Trade and Technology and Statistics Canada's list of establishments. The Made in Ontario data base includes the postal code and these establishments were located at the (six digit) postal code centroid. The centroid locations for postal codes were purchased from Statistics Canada. The Statistics Canada list only gives the municipality. These establishments were located at the centroid for the

municipal unit. The municipality centroid was calculated using SPANS.

To facilitate the calculation of depositions from different sources, a standard 4 km grid was created. Each establishment was moved to the nearest grid point, a distance of less than 2 km. Given that the initial location was the postal code or municipality centroid, this did not introduce a significant bias or error into the analysis. Grid points with numerous (over 10) establishments were examined. The larger firms assigned to that grid point were contacted and, if appropriate, shifted to other grid points. However, it remains true that establishments are artificially concentrated on some grid points due to the lack of accuracy of the address information. The establishments from the Statistics Canada list are concentrated at fewer locations because there are fewer municipalities than postal codes.

The attributes stored for each establishment are its:

- Canadian SIC code;
- estimated employment (or other size characteristic);
- estimated current emissions by contaminant;
- estimated emissions by contaminant for each implementation scenario; and
- an indicator to identify the appropriate dispersion pattern.

G.4.2 Determination of Concentrations

The dispersion modelling (see Appendix F) calculated 14 dispersion patterns for different parts of the province. The dispersion model assumed an emission rate of 1 gm/sec and calculated the resulting concentration (micrograms/cu.m) on a 2 km grid covering an area 24 km in all directions from the source.

To keep the calculations manageable -- 65 contaminants, over 3,500 establishments, 5 scenarios -- it was necessary to adopt a coarser grid. Thus, a 4 km grid rather than a 2 km grid was used. Since the sources had been moved to points on a 4 km grid, the concentration estimates also corresponded to points on this grid.

The analysis proceeds on a contaminant by contaminant basis. If an establishment is a source of the contaminant, the emissions for the specified scenario are converted to an emission rate. The appropriate dispersion pattern is selected. The origin of the dispersion pattern is adjusted to the source location. Every point in the dispersion grid is similarly adjusted to points on the province-wide grid. The concentration at each point on the dispersion grid is scaled by the emission rate and added to the existing concentration at that point on the province-wide grid.

When this process has been completed the grid points reflect the estimated concentration of the contaminant at that point due to emissions from all establishments under the given scenario. The concentration at each grid point is assumed to apply to a 4 km square area with the grid point at its centre.

G.4.3 Calculation of Ambient Concentration

The dispersion model estimates the concentration of a contaminant due to a specific source. Many of the contaminants analysed are also emitted by sources other than those considered in this study. Thus, the ambient concentration due to all sources is likely to be higher than the estimated emissions from the Regulation 308 sources covered by this study.

Data on total ambient concentrations are collected by monitoring stations. Two networks of monitoring stations exist in Ontario. One network has stations located in areas where air quality

problems are believed to exist. The other network has stations located more uniformly across the province to collect data to monitor acidic deposition. Each monitoring station collects information on ambient concentrations of a number of contaminants. Of the 96 contaminants, monitoring data are available for cadmium, chromium, lead, manganese, nickel, nitrogen oxides, nitrous oxide, sulphur dioxide, total particulate matter (PM) and total VOC's.

For each of these contaminants except total VOC's, the ambient concentration as recorded by the monitoring station was compared with the concentration at the monitoring station location estimated using the dispersion model. The result is a series of "residuals" (one for each monitoring station) that represent the ambient concentration due to non-Regulation 308 sources. These residuals were examined individually for each contaminant. Based on this examination, one (or more) values of the ambient concentration due to non-Regulation 308 sources were established. The value(s) and the rationale for the selection is presented in Chapter 4 in the section relating to the specific monitored contaminant.

The value(s) of the concentration due to non-Regulation 308 sources is added to the estimated concentration due to Regulation 308 sources at each grid point for all scenarios. This converts the value at each grid point from an estimate of the concentration due to the specific Regulation 308 sources analysed to an estimate of total ambient concentration. And it permits an analysis of the impact of the proposed changes to Regulation 308 on total ambient concentration of the given contaminant. The ambient concentration at each grid point is assumed to apply to a 4 km square area with the grid point at its centre.

This procedure is only possible for the nine contaminants -- cadmium, chromium, lead, manganese, nickel, nitrogen oxides, nitrous oxide, sulphur dioxide and PM -- for which monitoring data are available. The procedure was not used with VOC's because the monitoring stations report total VOC's and we did not have a reasonable basis for speciating this total at each monitoring station.

G.4.4 Maps of Environmental Resources at Risk

Having determined the geographic dispersion of a contaminant and its concentration at each point, it is necessary to relate that information to the resources at risk. These include humans, crops, livestock, forests and surface water. Maps of these resources were purchased from various sources and converted to SPANS format.

Population by enumeration area for the 1986 census was purchased from Statistics Canada. The enumeration area population totals were aggregated to the census subdivision level. The area of each census subdivision was calculated by SPANS. This allowed the population figure to be converted to a population density (people per sq. km). The population density is assumed to be uniform across the census subdivision.

Agricultural data from the 1986 Census of Agriculture were purchased from Statistics Canada. The information is available at the consolidated census sub-division level. Only the total crop acreage by consolidated census sub-division was mapped.

Forestry data were obtained from the National Forestry Service in Petawawa. A map of surface water for Ontario was purchased from the Canada Lands Directorate Service.

G.4.5 Analysis of Environmental Resources at Risk

For most contaminants, only the estimated emissions due to Regulation 308 sources are available. In these cases where the analysis can only identify the environmental resources at risk. The dispersion pattern for the contaminant is superimposed on the appropriate environmental resource(s), usually population. This is done for each scenario. The difference between the current resource exposure and the exposure under each scenario is calculated. This indicates the maximum change in environmental resources at risk by scenario.

In each of these cases, the estimated emissions due to Regulation 308 sources are also compared to the threshold values above which observable effects occur. In virtually every instance the current emissions are well below the threshold level.

G.4.6 Analysis of Contaminants for which Ambient Concentrations have been Estimated

The nine contaminants -- nickel, chromium, lead, manganese, nickel, nitrogen oxides, nitrous oxide, sulphur dioxide and PM -- for which total ambient concentrations are estimated are analysed in a manner similar to that outlined above.

The areas where the total ambient concentration exceeds the threshold value for observable effects is plotted for the existing situation and for each scenario for implementation of proposed changes to Regulation 308. The difference in the resources (population, crops, forests) exposed to above-threshold levels of the contaminant is a measure of the public benefits of the proposed revisions to Regulation 308.

G.4.7 Analysis of Cases with Exposure-Response and Damage Functions

In the case of cancer, and systemic health, visibility and soiling effects in the case of a few important contaminants, exposure-response and damage functions are available. These functions calculate the benefits of reduced exposure from the change in exposure and the population exposed.

For each scenario, the reduction in exposure from the existing level is calculated at each grid point. This change is multiplied by the population density in the 4 km square of which the grid point is the centre and by the area (16 km^2) to get the population and change in exposure. These values are summed over all relevant grid points and the aggregate values are used in the exposure-response and damage function to calculate the estimated benefits of reduced emissions.

Maps showing the dispersion patterns by contaminant are provided in Appendix I.

APPENDIX H

Exposure Response Functions

TABLE OF CONTENTS

APPENDIX H

	<u>Page</u>
H.1 INTRODUCTION	H - 1
H.2 CANCER FUNCTIONS	H - 1
H.3 NITROGEN DIOXIDE FUNCTIONS	H - 3
H.3.1 Eye Irritation	H - 3
H.3.2 Visibility Effects	H - 5
H.3.3 Materials Damage	H - 6
H.4 SULPHUR DIOXIDE FUNCTIONS	H - 7
H.4.1 Mortality	H - 7
H.4.2 Hospital Days for Respiratory Conditions	H - 7
H.4.3 Hospital Admissions for Respiratory Disease	H - 8
H.5 PARTICULATE MATTER FUNCTIONS	H - 8
H.5.1 Death	H - 9
H.5.2 Emergency Room Visits	H - 9
H.5.3 Restricted Activity Days	H - 10
H.5.4 Chronic Obstructive Pulmonary Disease	H - 10
H.5.5 Visibility Effects	H - 10
H.5.6 Materials Damage	H - 10
H.6 REFERENCES	H - 11

H.1 INTRODUCTION

An exposure-response function predicts how health and other factors, such as visibility and materials damage, change as the concentration of a contaminant changes. Exposure-response functions are the most commonly available for deaths by cancer. Functions are also available for other health effects from nitrogen dioxide, sulphur dioxide, and suspended particulate matter.

The exposure-response functions are discussed below for cancer and various effects of nitrogen dioxide, sulphur dioxide, and suspended particulate matter. The functions used are listed under the contaminant in question in Appendix C. They are elaborated here for greater clarity. For many non-cancer effects, upper, lower, and central values for the function are listed in Appendix C. We have calculated the lower and central value for each function.

H.2 CANCER FUNCTIONS

The change in cancer deaths due to a change in the concentration of a contaminant is predicted using a unit risk factor. The unit risk factors we used are usually IRIS (Integrated Risk Information System) values. Where IRIS values are not available, we used Massachusetts unit risk factors.

The change in annual cancer mortality from a change in the concentration of a chemical is calculated using the following formula:

$$ACM = URF \times CONC \times POP / 70$$

Where:

- ACM = Change in annual cancer mortality resulting from the change in concentration of the contaminant.
- URF = The IRIS (or Massachusetts) Unit Risk Factor.
- CONC = Change in concentration of the contaminant measured on an annual basis expressed in micrograms per cubic metre.
- POP = The population subject to the change in contaminant concentration.
- 70 = A factor converting lifetime (estimated to be 70 years) deaths to annual deaths.

The change in annual cancer mortality (ACM) is calculated for each contaminant for which a cancer unit risk factor is available. The calculation is performed for each of the implementation scenarios.

The calculation is performed as follows for a given contaminant and scenario. Each of the over 15,000 grid cells used in the analysis has a change in contaminant concentration specific to the contaminant and scenario (current concentration in micrograms per cubic meter as an annual average less projected concentration under the specified scenario in micrograms per cubic metre as an annual average). The change in contaminant concentration (CONC) for a grid cell is multiplied by the population (POP) of the grid cell. The products of these multiplications are summed over all grid cells. The sum is then multiplied by the cancer unit risk factor (URF) and divided by 70 to yield the change in annual cancer mortality.

Using arsenic as an example, the change in concentration multiplied by the population summed over all grid cells is as follows by scenario:

	Change in Concentration x Population	Unit Risk Factor	Change in Annual Cancer Mortality*
Scenarios "A" & "D"	117,335	4.3×10^{-3}	7.2
Scenario "B"	128,240	4.3×10^{-3}	7.9
Scenario "C"	105,577	4.3×10^{-3}	6.5
Scenario "E"	113,821	4.3×10^{-3}	7.0

* $117,335 \times 0.0043/70 = 7.2$

The unit risk factor for each carcinogen for which information is available is shown in Exhibit H.1.

H.3 NITROGEN DIOXIDE FUNCTIONS

Exposure-response functions for nitrogen dioxide have been developed for:

- . eye irritation;
- . visibility effects; and
- . materials damage.

The functions listed below are derived from the material presented in Appendix C.

H.3.1 Eye Irritation

The eye irritation damage function depends upon measurement of average daily high concentration of NO₂. We only had information on annual average concentration and therefore were unable to calculate changes eye irritation under the proposed implementation scenarios due to reduced emissions of NO₂.

EXHIBIT H.1: CANCER UNIT RISK FACTORS

<u>Contaminant</u>	<u>Unit Risk Factor</u>
Acrylonitrile	6.8×10^{-5}
Arsenic	4.3×10^{-3}
Asbestos	7.6×10^{-3}
Benzene	8.3×10^{-6}
1,3 Butadiene	2.8×10^{-4}
Cadmium	1.8×10^{-4}
Carbon Tetrachloride	1.5×10^{-5}
Chloroform	2.3×10^{-5}
Chromium	1.2×10^{-2}
Epichlorohydrin	1.2×10^{-6}
Ethylene Dichloride	2.6×10^{-5}
Formaldehyde	1.3×10^{-5}
Methylene Chloride	4.1×10^{-6}
Nickel	4.8×10^{-4}
Polychlorinated Biphenols	2.2×10^{-3}
Propylene Oxide	6.67×10^{-7}
Styrene	5.7×10^{-7}
Toluene Diisocyanate	6.79×10^{-6}
1,1,1-Trichloroethane (Methyl Chloroform)	1.6×10^{-5}
Trichloroethylene	1.3×10^{-6}
Vinyl Chloride	2.6×10^{-6}

H.3.2 Visibility Effects

We adjusted the function given in Appendix C as follows:

$$\begin{aligned} \text{Total} \\ \text{Value} &= E \times 205 \times \ln [1/(1-\{0.035 \times (\text{NO}_2A - \text{NO}_2B) \times \\ \text{Per Year} &\quad 100/\text{NO}_2A\})] \times \text{POP/HF} \end{aligned}$$

Where:

- E = The mean 1986 rate of exchange (1.3894) to convert 1986 U.S. to 1986 Canadian dollars.
- ln = The natural logarithm.
- 0.035 = A mean value for the function, which varies according to urban or rural location. (Taking a mean value biases the result, but the difference between urban and rural location is not as great as the upper and lower bounds for this function.)
- NO_2A = The current NO_2 concentration for the grid cell.
- NO_2B = The NO_2 concentration for the same grid cell under the specified implementation scenario.
- POP = The population of the grid cell.
- HF = A factor (2.8) to convert population to the number of households.

The function given above is the central case estimate. To get the lower bound estimate, the constant 205 is replaced by 100. In other words, the lower bound is equal to the central case divided by 2.05.

As was the case for the cancer mortality equation, the calculation is performed for each of the over 15,000 grid cells

and then summed. Specifically,

$$\ln [1/(1-(0.035 \times (\text{NO}_2\text{A} - \text{NO}_2\text{B}) \times 100/\text{NO}_2\text{A}))] \times \text{POP/HF}$$

is calculated for each grid cell. These values are then summed over all grid cells. And the sum is multiplied by $E \times 205$ to get the final result.

Note that the output is a dollar value; there is no physical value such as "number of days of poor visibility", analogous to the number of deaths, hospital days, etc. in the other functions.

H.3.3 Materials Damage

The materials damage function for nitrogen dioxide is expressed in similar terms. The equation describes the annual materials damage value per person. For the central case, the materials damage equation is:

$$\begin{array}{l} \text{Total} \\ \text{Value} = E \times 1.51 \times [(\text{NO}_2\text{A} - \text{NO}_2\text{B}) \times 100/\text{NO}_2\text{A}] \times \text{POP} \\ \text{Per Year} \end{array}$$

The symbols have the same meaning as in the visibility equation. Thus, materials damage is a function of the percentage change in nitrogen dioxide concentration and population.

The function shown above is the central case. The lower bound is calculated as 0.5 times the central case.

H.4 SULPHUR DIOXIDE FUNCTIONS

H.4.1 Mortality

An exposure-response function is available for deaths attributable to sulphur dioxide. The function in Appendix C is adjusted as follows to calculate absolute change in the number of annual deaths.

$$\text{Deaths} = 2.672 \times 10^{-5} \times \text{POP} \times (\text{SO}_{2A} - \text{SO}_{2B})$$

Where:

- SO_{2A} = The SO_2 concentration for a grid cell under existing regulations.
- SO_{2B} = The SO_2 concentration for a grid cell under a specific implementation scenario.
- POP = The population of a grid cell.

The function presented above is the central case estimate for reduction in annual mortality due to reduced concentrations of sulphur dioxide. The low case is calculated by applying the lower bound estimate of the value of a statistical life to the calculated reduction in mortality.

H.4.2 Hospital Days for Respiratory Conditions

The function of hospital days for respiratory conditions (HDRC) is:

$$\text{HDRC} = 4.0 \times 10^{-4} \times (\text{SO}_{2A} - \text{SO}_{2B}) \times \text{POP}$$

The variables SO_{2A} , SO_{2B} and POP have the same meaning as in the mortality equation.

The lower bound estimate is obtained by replacing 4.0×10^{-4} in the central case equation presented above with 1.5×10^{-4} . In other words the lower bound is 0.375 times the central case.

H.4.3 Hospital Admissions for Respiratory Disease

The function for hospital admissions for respiratory disease (HARD) is:

$$\text{HARD} = 4.065 \times 10^{-5} \times (\text{SO}_2\text{A} - \text{SO}_2\text{B}) \times \text{POP}$$

The variables SO_2A , SO_2B and POP have the same meaning as in the mortality equation.

The lower bound estimate is calculated by replacing 4.065×10^{-5} in the central case equation presented above with 0.63×10^{-5} . Alternately, the lower bound is 0.155 times the central case.

H.5 PARTICULATE MATTER FUNCTIONS

Six exposure response functions exist for PM. They relate to:

- . death;
- . emergency room visits;
- . restricted activity days;
- . chronic obstructive pulmonary disease;
- . visibility; and
- . materials damage.

The functions below are derived from those in Appendix C. In each case:

- PM_A = The original PM concentration for a grid cell.
- PM_B = The PM concentration for a grid cell under the scenario considered.
- E = The mean 1986 rate of exchange (1.3894) to convert 1986 U.S. to 1986 Canadian dollars.
- HF = A factor (2.8) to convert the population of a grid cell to the number of households.
- POP = The population of a grid cell.

H.5.1 Death

$$\text{Deaths} = 2.21 \times 10^{-6} \times POP \times (PM_A - PM_B)$$

This equation gives the change in annual deaths due to a change in particulate matter concentration. The lower bound and central value are calculated by applying the corresponding values of a statistical life to the reduction in annual mortality estimated using the above equation.

H.5.2 Emergency Room Visits

$$ERV = 1.3 \times 10^{-4} \times POP \times (PM_A - PM_B)$$

The change in the number of emergency room visits per year, ERV, is related to the change in particulate matter concentration. The lower bound estimate of emergency room visits is calculated by replacing the central case coefficient of 1.3×10^{-4} by 1.2×10^{-5} .

H.5.3 Restricted Activity Days

$$RAD = 2.736 \times 10^{-2} \times POP \times (PM_A - PM_B) - \text{Emergency Room Visits}$$

The change in the number of restricted activity days, RAD, is reduced by the change in the number of emergency room visits (ERV) to avoid double counting. The lower bound estimate of restricted activity days is calculated by replacing the central case coefficient of 2.736×10^{-2} by 1.938×10^{-2} . In other words, the lower bound is equal to 0.70833 times the central case.

H.5.4 Chronic Obstructive Pulmonary Disease

The function in Appendix C deals with changes in risk of pulmonary disease in adults and children. It does not predict actual change in, or values relating to, pulmonary disease. It was therefore impractical to use it in the analysis.

H.5.5 Visibility Effects

$$\begin{aligned} \text{Total} \\ \text{Value} &= E \times 206 \times \ln (PM_A/PM_B) \times POP/HF \\ \text{Per Year} \end{aligned}$$

The lower bound estimate is calculated as 0.5 times the central case.

As with visibility effects from nitrogen dioxide, this function returns an annual dollar value for improved visibility.

H.5.6 Materials Damage

$$\begin{aligned} \text{Total} \\ \text{Value} &= E \times 7.4 \times (PM_A - PM_B) \times POP/HF \\ \text{Per Year} \end{aligned}$$

This function also returns an annual dollar value of reduced materials damage.

To get the lower bound estimate, the central case coefficient of 7.4 is replaced by 0.52. In other words, the lower bound is 0.07027 times the central case.

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APPENDIX I

Maps

TABLE OF CONTENTS

APPENDIX I

	<u>Page</u>
Exhibit I.1: Areas Exposed To Acrylonitrile From Regulation 308 Source Emissions	I - 1
Exhibit I.2: Location Of The Line Along Which The Concentration Profile Is Calculated	I - 2
Exhibit I.3: Areas Exposed To Arsenic From Regulation 308 Source Emissions.	I - 3
Exhibit I.4: Profile Of Arsenic Concentration Due To Regulation 308 Source Emissions Across Southern Ontario.	I - 4
Exhibit I.5: Areas Exposed To Asbestos From Regulation 308 Source Emissions.	I - 5
Exhibit I.6: Profile of Asbestos Concentration Due To Regulation 308 Source Emissions Across Southern Ontario.	I - 6
Exhibit I.7: Areas Exposed To Benzene From Regulation 308 Source Emissions.	I - 7
Exhibit I.8: Profile Of Benzene Concentration Due To Regulation 308 Source Emissions Across Southern Ontario.	I - 8
Exhibit I.9: Areas Exposed To 1,3 Butadiene From Regulation 308 Source Emissions	I - 9
Exhibit I.10: Profile Of 1,3 Butadiene Concentration Due To Regulation 308 Source Emissions Across Southern Ontario.	I - 10
Exhibit I.11: Areas Exposed To 2-Butanone From Regulation 308 Source Emissions.	I - 11
Exhibit I.12: Profile of 2-Butanone Concentrations Due To Regulation 308 Source Emissions Across Southern Ontario.	I - 12
Exhibit I.13: Areas Exposed To Butyl Acrylate From Regulation 308 Source Emissions	I - 13
Exhibit I.14: Profile of Butyl Acrylate Concentrations Due To Regulation 308 Source Emissions Across Southern Ontario	I - 14

TABLE OF CONTENTS

APPENDIX I

Continued

	<u>Page</u>
Exhibit I.15: Areas Exposed To Cadmium From Regulation 308 Source Emissions.	I - 15
Exhibit I.16: Profile of Cadmium Concentrations Due To Regulation 308 Source Emissions Across Southern Ontario.	I - 16
Exhibit I.17: Areas Exposed To Carbon Tetrachloride From Regulation 308 Source Emissions	I - 17
Exhibit I.18: Profile of Carbon Tetrachloride Concentrations Due To Regulation 308 Source Emissions Across Southern Ontario	I - 18
Exhibit I.19: Areas Exposed To CDD's From Regulation 308 Source Emissions.	I - 19
Exhibit I.20: Profile of CDD Concentrations Due To Regulation 308 Source Emissions Across Southern Ontario.	I - 20
Exhibit I.21: Areas Exposed To CDF's From Regulation 308 Source Emissions.	I - 21
Exhibit I.22: Profile of CDF Concentrations Due To Regulation 308 Source Emissions Across Southern Ontario.	I - 22
Exhibit I.23: Areas Exposed To Chlorine From Regulation 308 Source Emissions.	I - 23
Exhibit I.24: Profile of Chlorine Concentrations Due To Regulation 308 Source Emissions Across Southern Ontario.	I - 24
Exhibit I.25: Areas Exposed To Chlorine Dioxide From Regulation 308 Source Emissions	I - 25
Exhibit I.26: Profile of Chlorine Dioxide Concentrations Due To Regulation 308 Source Emissions Across Southern Ontario	I - 26
Exhibit I.27: Areas Exposed To Chloroform From Regulation 308 Source Emissions.	I - 27

TABLE OF CONTENTS

APPENDIX I

Continued

	<u>Page</u>
Exhibit I.28: Profile of Chloroform Concentrations Due To Regulation 308 Source Emissions Across Southern Ontario.	I - 28
Exhibit I.29: Areas Exposed To Chromium From Regulation 308 Source Emissions.	I - 29
Exhibit I.30: Profile of Chromium Concentrations Due To Regulation 308 Source Emissions Across Southern Ontario.	I - 30
Exhibit I.31: Areas Exposed To Epichlorohydrin From Regulation 308 Source Emissions	I - 31
Exhibit I.32: Profile of Epichlorohydrin Concentrations Due To Regulation 308 Source Emissions Across Southern Ontario	I - 32
Exhibit I.33: Areas Exposed To Ethyl Benzene From Regulation 308 Source Emissions	I - 33
Exhibit I.34: Profile of Ethyl Benzene Concentrations Due To Regulation 308 Source Emissions Across Southern Ontario.	I - 34
Exhibit I.35: Areas Exposed To Ethylene From Regulation 308 Source Emissions.	I - 35
Exhibit I.36: Profile of Ethylene Concentrations Due To Regulation 308 Source Emissions Across Southern Ontario.	I - 36
Exhibit I.37: Areas Exposed To Ethylene Dibromide From Regulation 308 Source Emissions	I - 37
Exhibit I.38: Profile of Ethylene Dibromide Concentrations Due To Regulation 308 Source Emissions Across Southern Ontario.	I - 38
Exhibit I.39: Areas Exposed To Ethylene Dichloride From Regulation 308 Source Emissions	I - 39

TABLE OF CONTENTS

APPENDIX I

Continued

	<u>Page</u>
Exhibit I.40: Profile of Ethylene Dichloride Concentrations Due To Regulation 308 Source Emissions Across Southern Ontario.	I - 40
Exhibit I.41: Areas Exposed To Butyl Cellosolve From Regulation 308 Source Emissions	I - 41
Exhibit I.42: Profile of Butyl Cellosolve Concentrations Due To Regulation 308 Source Emissions Across Southern Ontario.	I - 42
Exhibit I.43: Areas Exposed To Cellosolve From Regulation 308 Source Emissions.	I - 43
Exhibit I.44: Profile of Cellosolve Concentrations Due To Regulation 308 Source Emissions Across Southern Ontario.	I - 44
Exhibit I.45: Areas Exposed To Cellosolve Acetate From Regulation 308 Source Emissions	I - 45
Exhibit I.46: Profile of Cellosolve Acetate Concentrations Due To Regulation 308 Source Emissions Across Southern Ontario.	I - 46
Exhibit I.47: Areas Exposed To Ethylene Oxide From Regulation 308 Source Emissions	I - 47
Exhibit I.48: Profile of Ethylene Oxide Concentrations Due To Regulation 308 Source Emissions Across Southern Ontario.	I - 48
Exhibit I.49: Areas Exposed To Fluorides From Regulation 308 Source Emissions.	I - 49
Exhibit I.50: Profile of Fluorides Concentrations Due To Regulation 308 Source Emissions Across Southern Ontario.	I - 50
Exhibit I.51: Areas Exposed To Formaldehyde From Regulation 308 Source Emissions.	I - 51
Exhibit I.52: Profile of Formaldehyde Concentrations Due To Regulation 308 Source Emissions Across Southern Ontario.	I - 52

TABLE OF CONTENTS

APPENDIX I

Continued

	<u>Page</u>
Exhibit I.53: Areas Exposed To Hydrogen Chloride From Regulation 308 Source Emissions	I - 53
Exhibit I.54: Profile of Hydrogen Chloride Concentrations Due To Regulation 308 Source Emissions Across Southern Ontario.	I - 54
Exhibit I.55: Areas Exposed To Lead From Regulation 308 Source Emissions.	I - 55
Exhibit I.56: Profile of Lead Concentrations Due To Regulation 308 Source Emissions Across Southern Ontario.	I - 56
Exhibit I.57: Areas Exposed To Manganese Compounds From Regulation 308 Source Emissions	I - 57
Exhibit I.58: Profile of Manganese Compounds Concentrations Due To Regulation 308 Source Emissions Across Southern Ontario.	I - 58
Exhibit I.59: Areas Exposed To Mercury From Regulation 308 Source Emissions.	I - 59
Exhibit I.60: Profile of Mercury Concentrations Due To Regulation 308 Source Emissions Across Southern Ontario.	I - 60
Exhibit I.61: Areas Exposed To Methyl Isobutyl Ketone From Regulation 308 Source Emissions	I - 61
Exhibit I.62: Profile of Methyl Isobutyl Ketone Concentrations Due To Regulation 308 Source Emissions Across Southern Ontario	I - 62
Exhibit I.63: Areas Exposed To Methylen Chloride From Regulation 308 Source Emissions	I - 63
Exhibit I.64: Profile of Methylen Chloride Concentrations Due To Regulation 308 Source Emissions Across Southern Ontario.	I - 64
Exhibit I.65: Areas Exposed To Naphthalene From Regulation 308 Source Emissions.	I - 65

TABLE OF CONTENTS

APPENDIX I

Continued

	<u>Page</u>
Exhibit I.66: Profile of Naphthalene Concentrations Due To Regulation 308 Source Emissions Across Southern Ontario.	I - 66
Exhibit I.67: Areas Exposed To Nickel From Regulation 308 Source Emissions.	I - 67
Exhibit I.68: Profile of Nickel Concentrations Due To Regulation 308 Source Emissions Across Southern Ontario.	I - 68
Exhibit I.69: Areas Exposed To Nitrogen Oxides From Regulation 308 Source Emissions	I - 69
Exhibit I.70: Profile of Nitrogen Oxides Concentrations Due To Regulation 308 Source Emissions Across Southern Ontario.	I - 70
Exhibit I.71: Areas Exposed To Perchloroethylene From Regulation 308 Source Emissions	I - 71
Exhibit I.72: Profile of Perchloroethylene Concentrations Due To Regulation 308 Source Emissions Across Southern Ontario.	I - 72
Exhibit I.73: Areas Exposed To Phenol From Regulation 308 Source Emissions.	I - 73
Exhibit I.74: Profile of Phenol Concentrations Due To Regulation 308 Source Emissions Across Southern Ontario.	I - 74
Exhibit I.75: Areas Exposed To Polychlorinated Biphenyls From Regulation 308 Source Emissions.	I - 75
Exhibit I.76: Profile of Polychlorinated Biphenyls Concentrations Due To Regulation 308 Source Emissions Across Southern Ontario	I - 76
Exhibit I.77: Areas Exposed To Propionaldehyde From Regulation 308 Source Emissions	I - 77

TABLE OF CONTENTS

APPENDIX I

Continued

	<u>Page</u>
Exhibit I.78: Profile of Propionaldehyde Concentrations Due To Regulation 308 Source Emissions Across Southern Ontario.	I - 78
Exhibit I.79: Areas Exposed To Propionic Acid From Regulation 308 Source Emissions	I - 79
Exhibit I.80: Profile of Propionic Acid Concentrations Due To Regulation 308 Source Emissions Across Southern Ontario.	I - 80
Exhibit I.81: Areas Exposed To Propylene Oxide From Regulation 308 Source Emissions	I - 81
Exhibit I.82: Profile of Propylene Oxide Concentrations Due To Regulation 308 Source Emissions Across Southern Ontario.	I - 82
Exhibit I.83: Areas Exposed To Selenium From Regulation 308 Source Emissions.	I - 83
Exhibit I.84: Profile of Selenium Concentrations Due To Regulation 308 Source Emissions Across Southern Ontario.	I - 84
Exhibit I.85: Areas Exposed To Silica From Regulation 308 Source Emissions.	I - 85
Exhibit I.86: Profile of Silica Concentrations Due To Regulation 308 Source Emissions Across Southern Ontario.	I - 86
Exhibit I.87: Areas Exposed To Styrene From Regulation 308 Source Emissions.	I - 87
Exhibit I.88: Profile of Styrene Concentrations Due To Regulation 308 Source Emissions Across Southern Ontario.	I - 88
Exhibit I.89: Areas Exposed To Sulphur Dioxide From Regulation 308 Source Emissions	I - 89
Exhibit I.90: Profile of Sulphur Dioxide Concentrations Due To Regulation 308 Source Emissions Across Southern Ontario.	I - 90

TABLE OF CONTENTS

APPENDIX I

Continued

	<u>Page</u>
Exhibit I.91: Areas Exposed To Suspended Particulate Matter From Regulation 308 Source Emissions. . . .	I - 91
Exhibit I.92: Profile of Total Particulate Concentrations Due To Regulation 308 Source Emissions Across Southern Ontario.	I - 92
Exhibit I.93: Areas Exposed To Tin From Regulation 308 Source Emissions.	I - 93
Exhibit I.94: Profile of Tin Concentrations Due To Regulation 308 Source Emissions Across Southern Ontario.	I - 94
Exhibit I.95: Areas Exposed To Toluene From Regulation 308 Source Emissions.	I - 95
Exhibit I.96: Profile of Toluene Concentrations Due To Regulation 308 Source Emissions Across Southern Ontario.	I - 96
Exhibit I.97: Areas Exposed To Toluene Diisocyanate From Regulation 308 Source Emissions	I - 97
Exhibit I.98: Profile of Toluene Diisocyanate Concentrations Due To Regulation 308 Source Emissions Across Southern Ontario	I - 98
Exhibit I.99: Areas Exposed To 1,1,1-Trichloroethane From Regulation 308 Source Emissions	I - 99
Exhibit I.100: Profile of 1,1,1-Trichloroethane Concentrations Due To Regulation 308 Source Emissions Across Southern Ontario	I - 100
Exhibit I.101: Areas Exposed To Trichlorobenzenes From Regulation 308 Source Emissions	I - 101
Exhibit I.102: Profile of Trichlorobenzenes Concentrations Due To Regulation 308 Source Emissions Across Southern Ontario.	I - 102
Exhibit I.103: Areas Exposed To Trichloroethylene From Regulation 308 Source Emissions	I - 103

TABLE OF CONTENTS

APPENDIX I

Continued

	<u>Page</u>
Exhibit I.104: Profile of Trichloroethylene Concentrations Due To Regulation 308 Source Emissions Across Southern Ontario.	I.- 104
Exhibit I.105: Areas Exposed To Vinyl Chloride From Regulation 308 Source Emissions	I.- 105
Exhibit I.106: Profile of Vinyl Chloride Concentrations Due To Regulation 308 Source Emissions Across Southern Ontario.	I.- 106
Exhibit I.107: Areas Exposed To Xylenes From Regulation 308 Source Emissions.	I.- 107
Exhibit I.108: Profile of Xylenes Concentrations Due To Regulation 308 Source Emissions Across Southern Ontario.	I.- 108

EXHIBIT I.1: AREAS EXPOSED TO ACRYLONITRILE FROM REGULATION 308 SOURCE EMISSIONS

I - 1

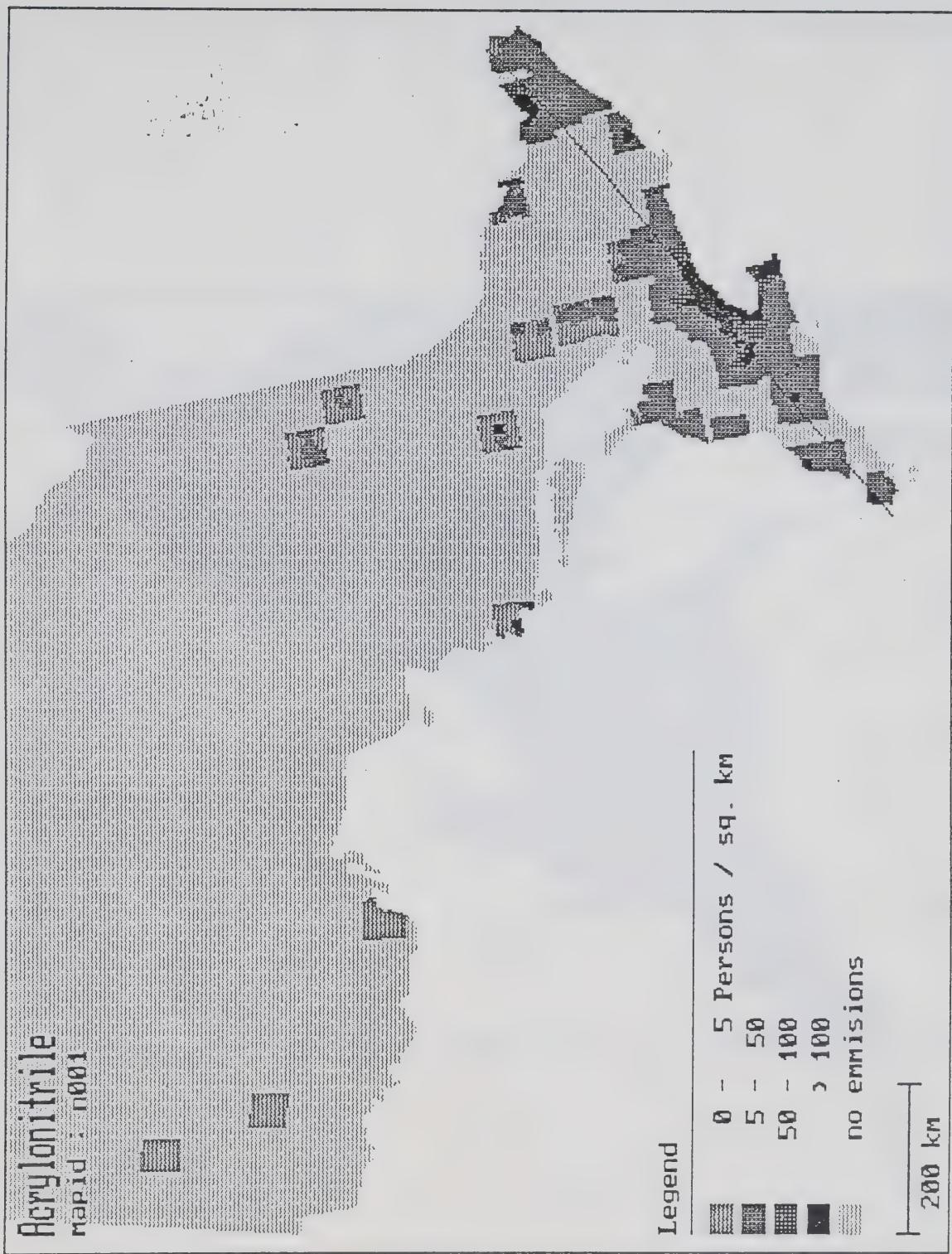


EXHIBIT I.2: LOCATION OF THE LINE ALONG WHICH THE CONCENTRATION PROFILE IS CALCULATED

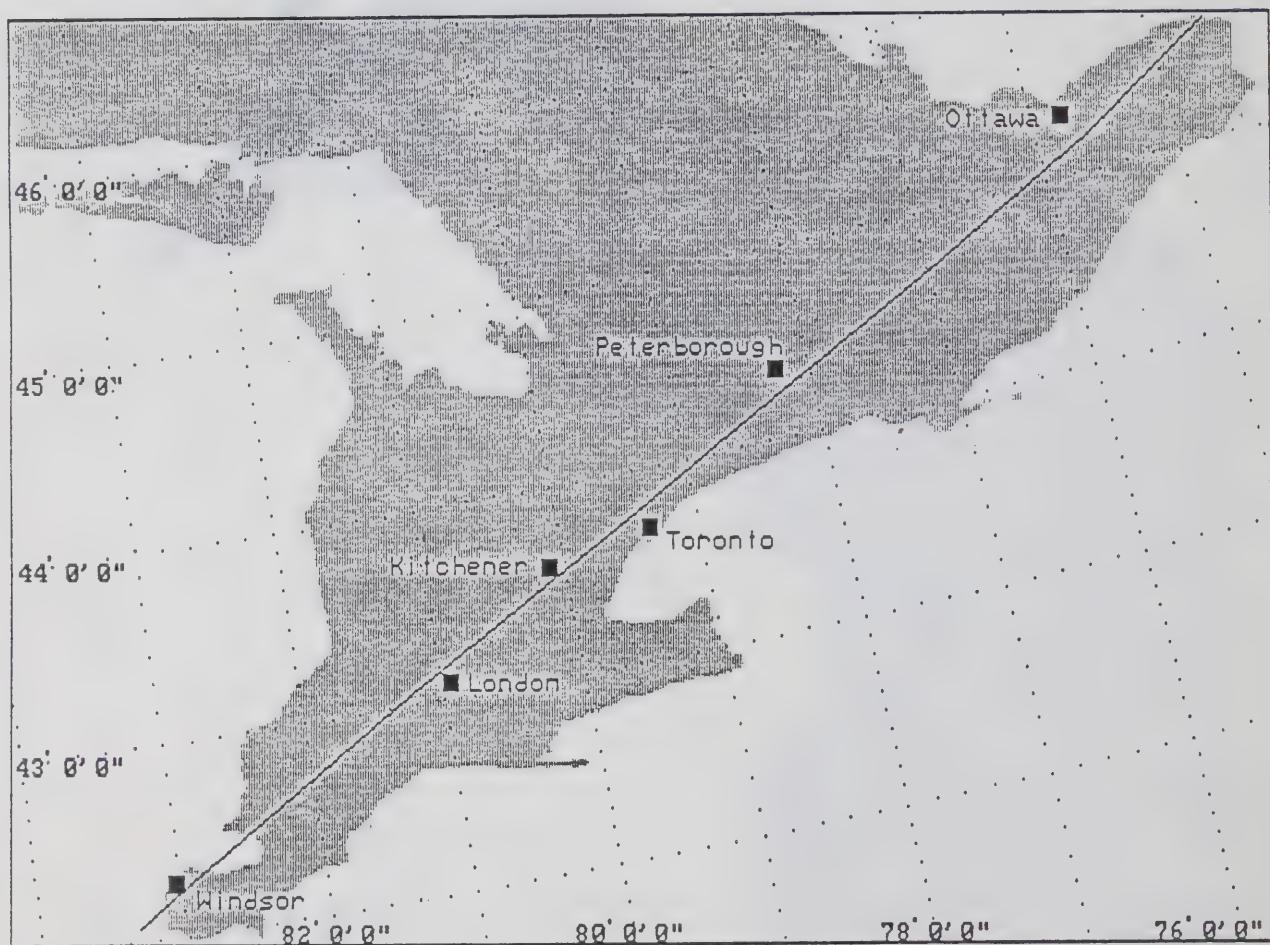


EXHIBIT I.3: AREAS EXPOSED TO ARSENIC FROM REGULATION 308 SOURCE EMISSIONS

I - 3

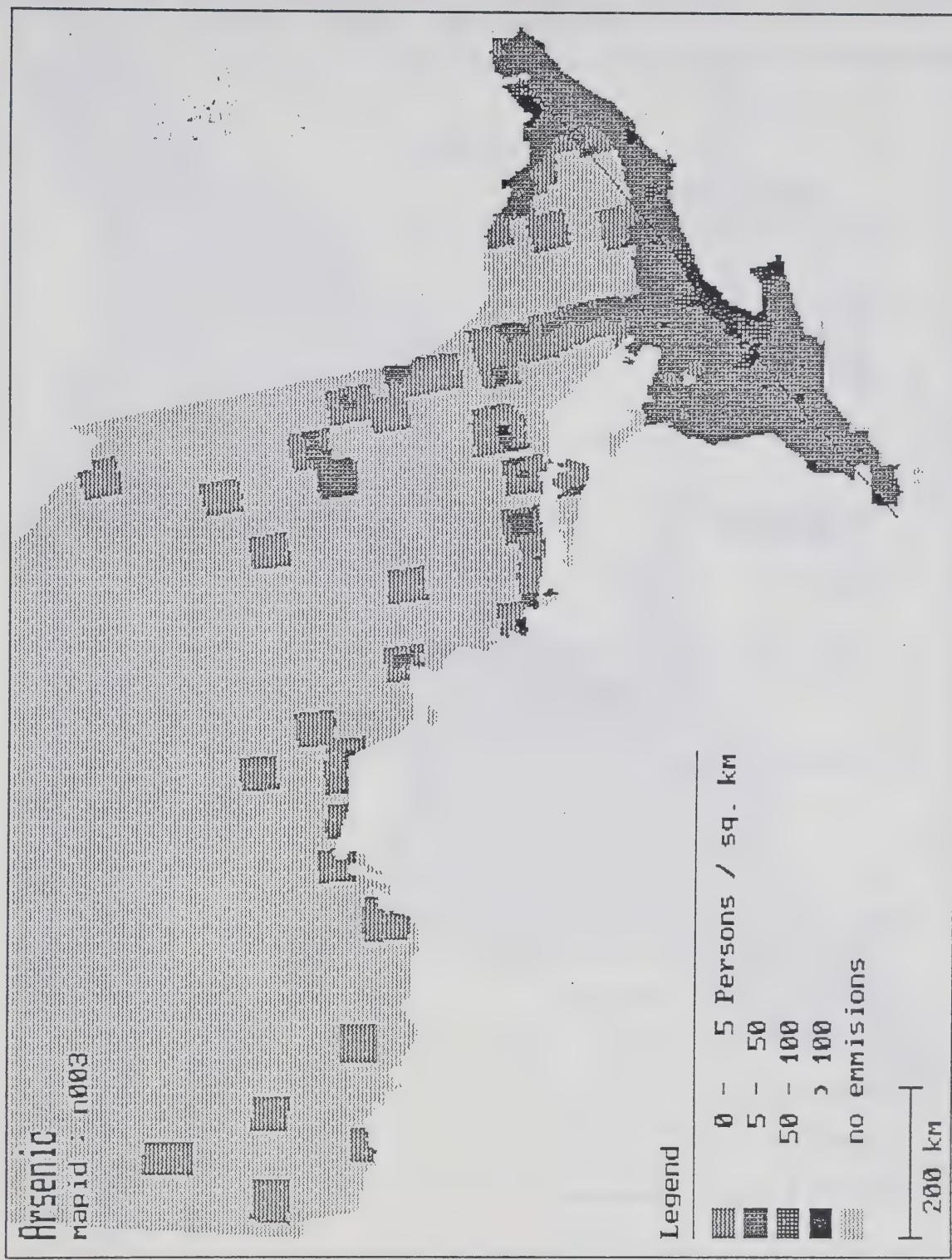
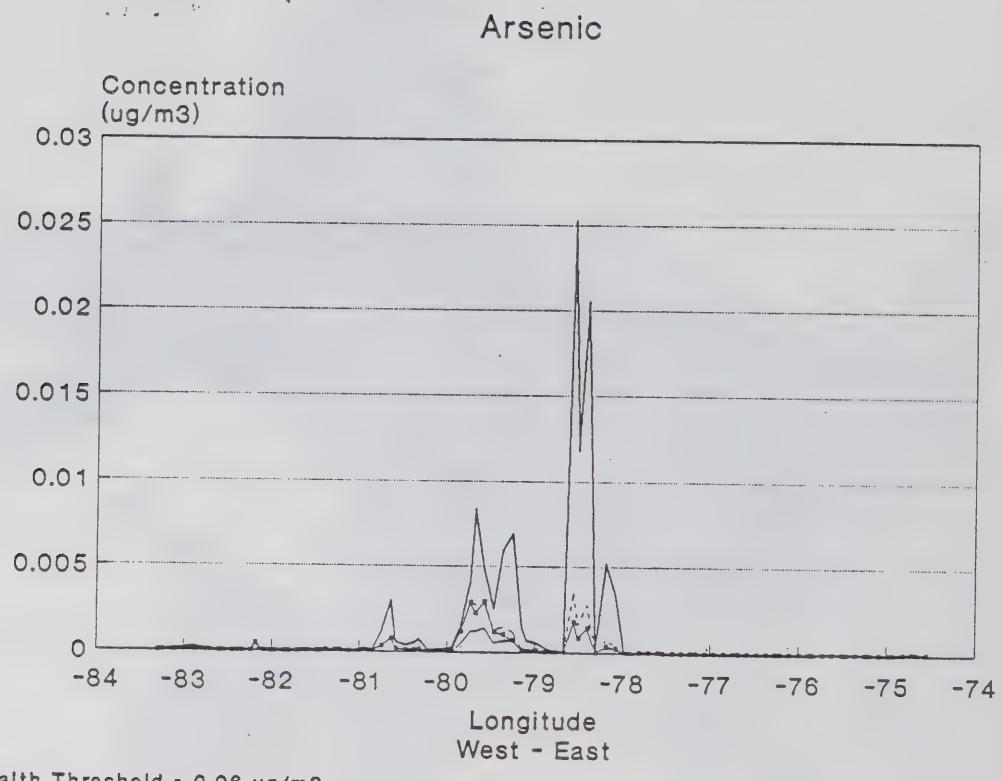


EXHIBIT I.4: PROFILE OF ARSENIC CONCENTRATION DUE TO REGULATION
308 SOURCE EMISSIONS ACROSS SOUTHERN ONTARIO



Legend

- | | |
|-----------------|-------|
| Existing | _____ |
| Scenarios A & D | _____ |
| Scenario B | _____ |
| Scenario C | ----- |
| Scenario E | ..... |

EXHIBIT I.5: AREAS EXPOSED TO ASBESTOS FROM REGULATION 308 SOURCE EMISSIONS

I - 5

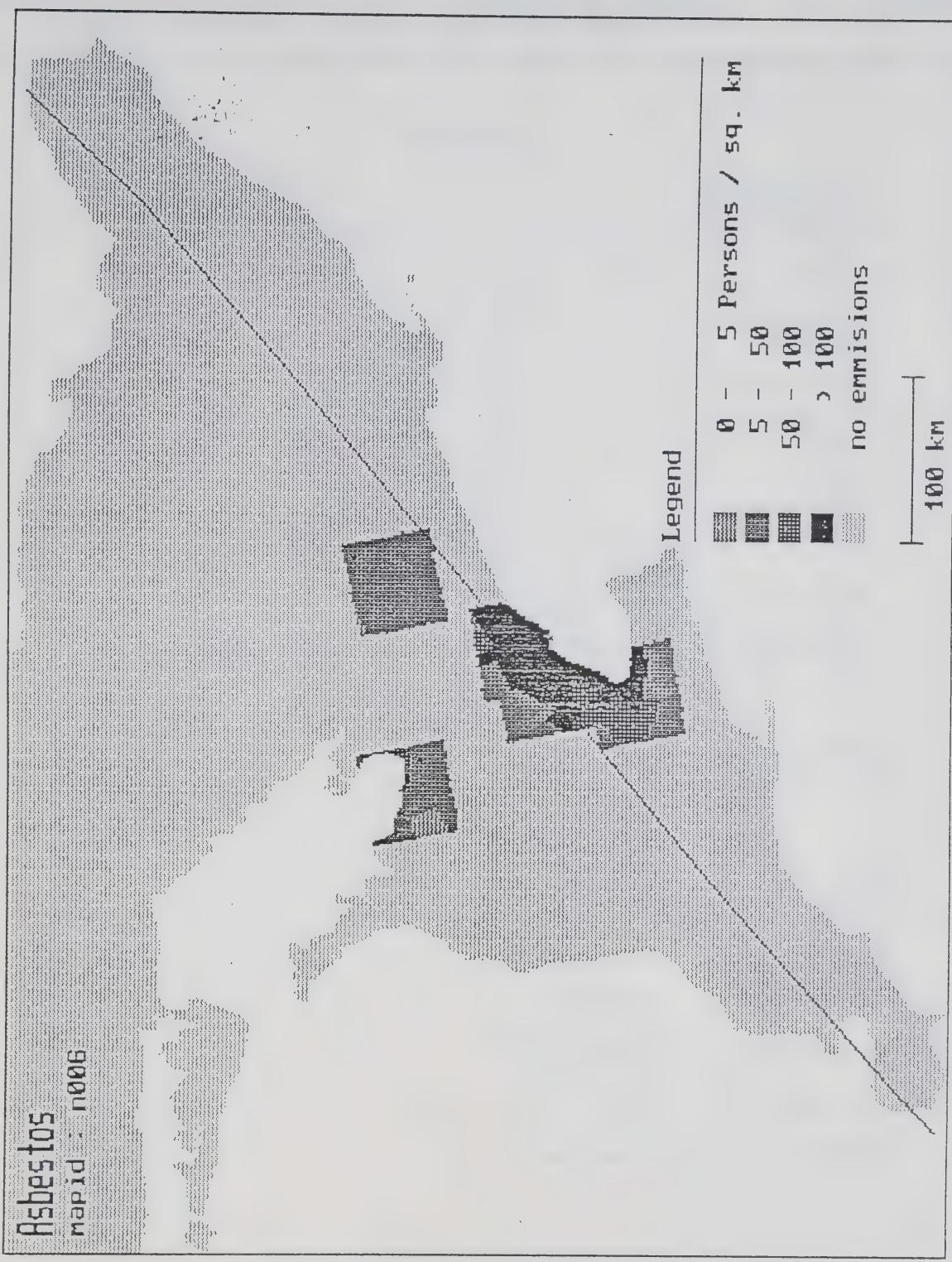
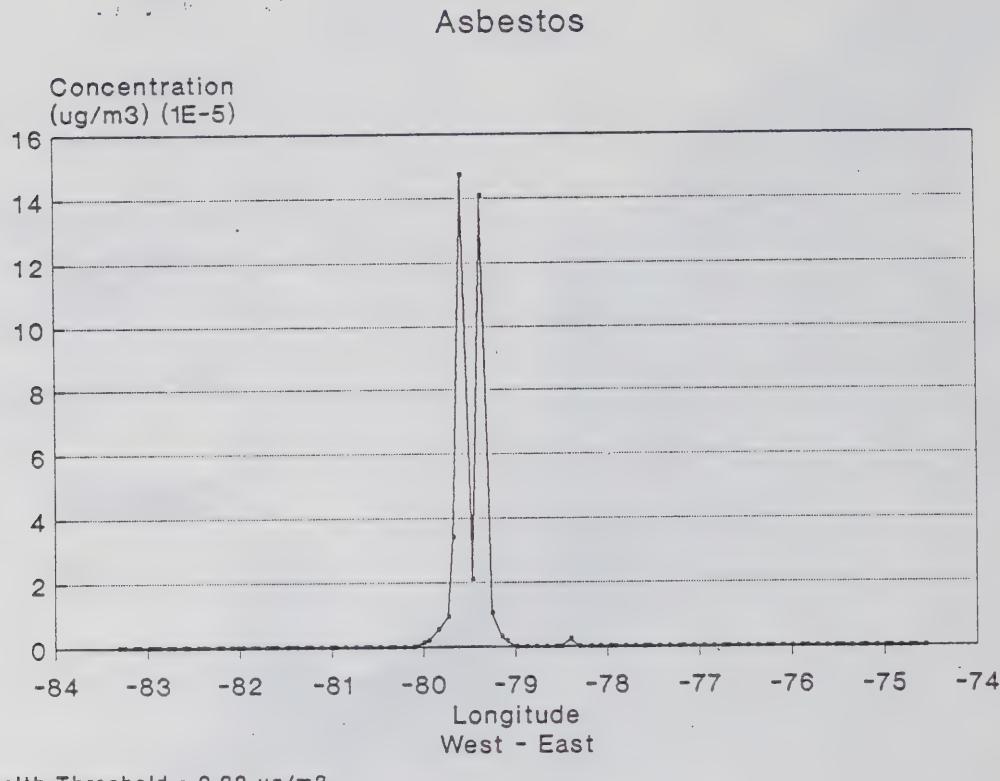


EXHIBIT I.6: PROFILE OF ASBESTOS CONCENTRATION DUE TO REGULATION
308 SOURCE EMISSIONS ACROSS SOUTHERN ONTARIO



Legend

- Existing _____
- Scenarios A & D _____
- Scenario B _____
- Scenario C -----
- Scenario E *****

EXHIBIT I.7: AREAS EXPOSED TO BENZENE FROM REGULATION 308 SOURCE EMISSIONS

I - 7

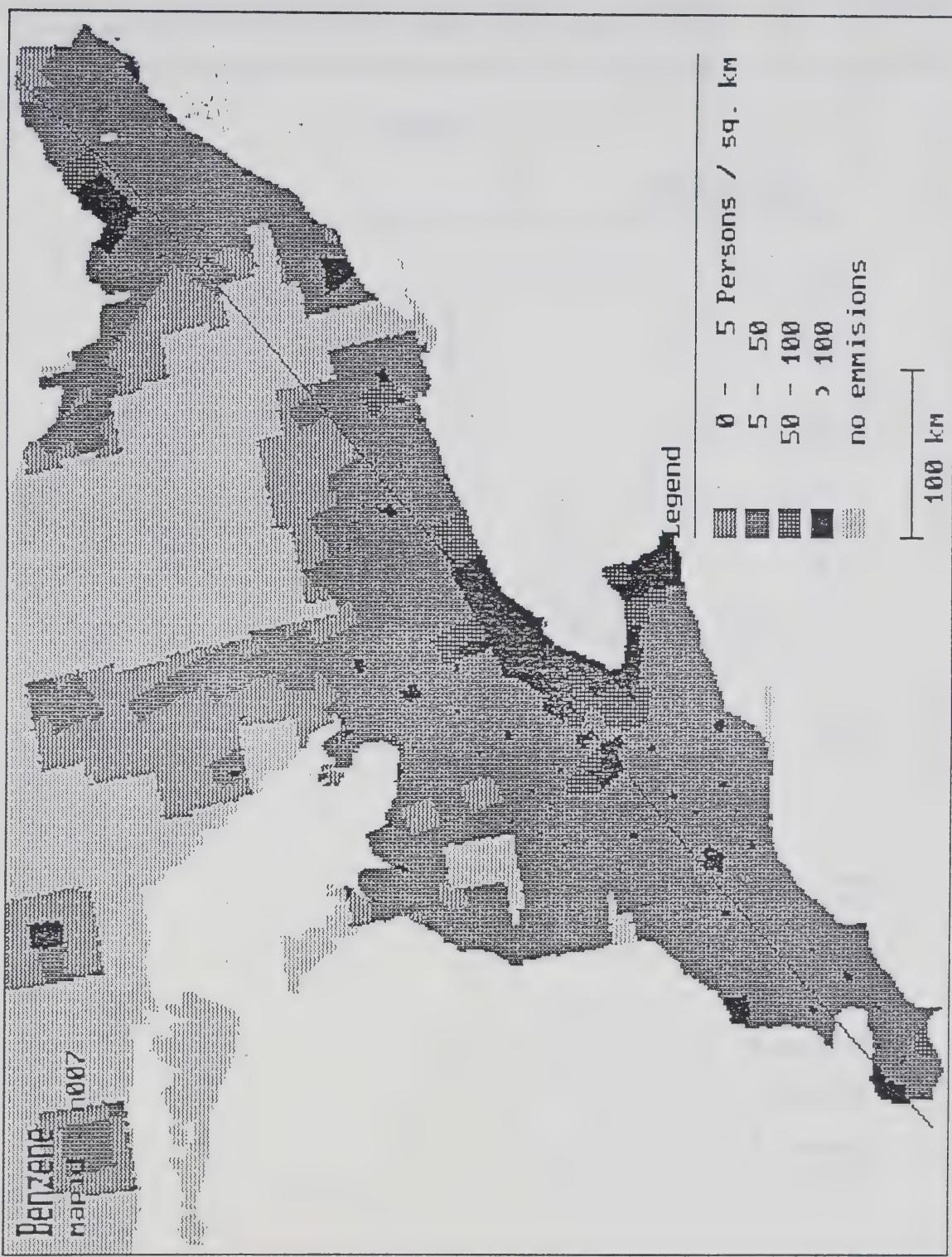
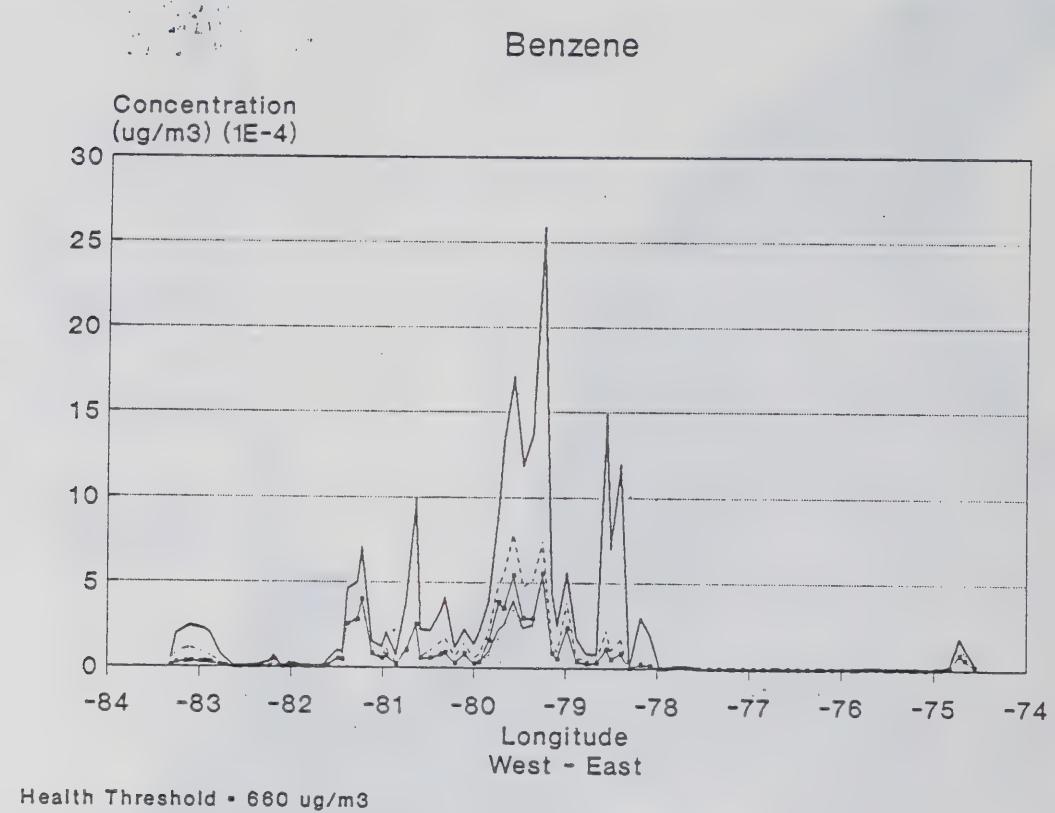


EXHIBIT I.8: PROFILE OF BENZENE CONCENTRATION DUE TO REGULATION
308 SOURCE EMISSIONS ACROSS SOUTHERN ONTARIO



Legend

- Existing _____
 - Scenarios A & D _____
 - Scenario B _____
 - Scenario C -----
 - Scenario E *****
-

EXHIBIT I.9: AREAS EXPOSED TO 1,3 BUTADIENE FROM REGULATION 308 SOURCE EMISSIONS

I - 9

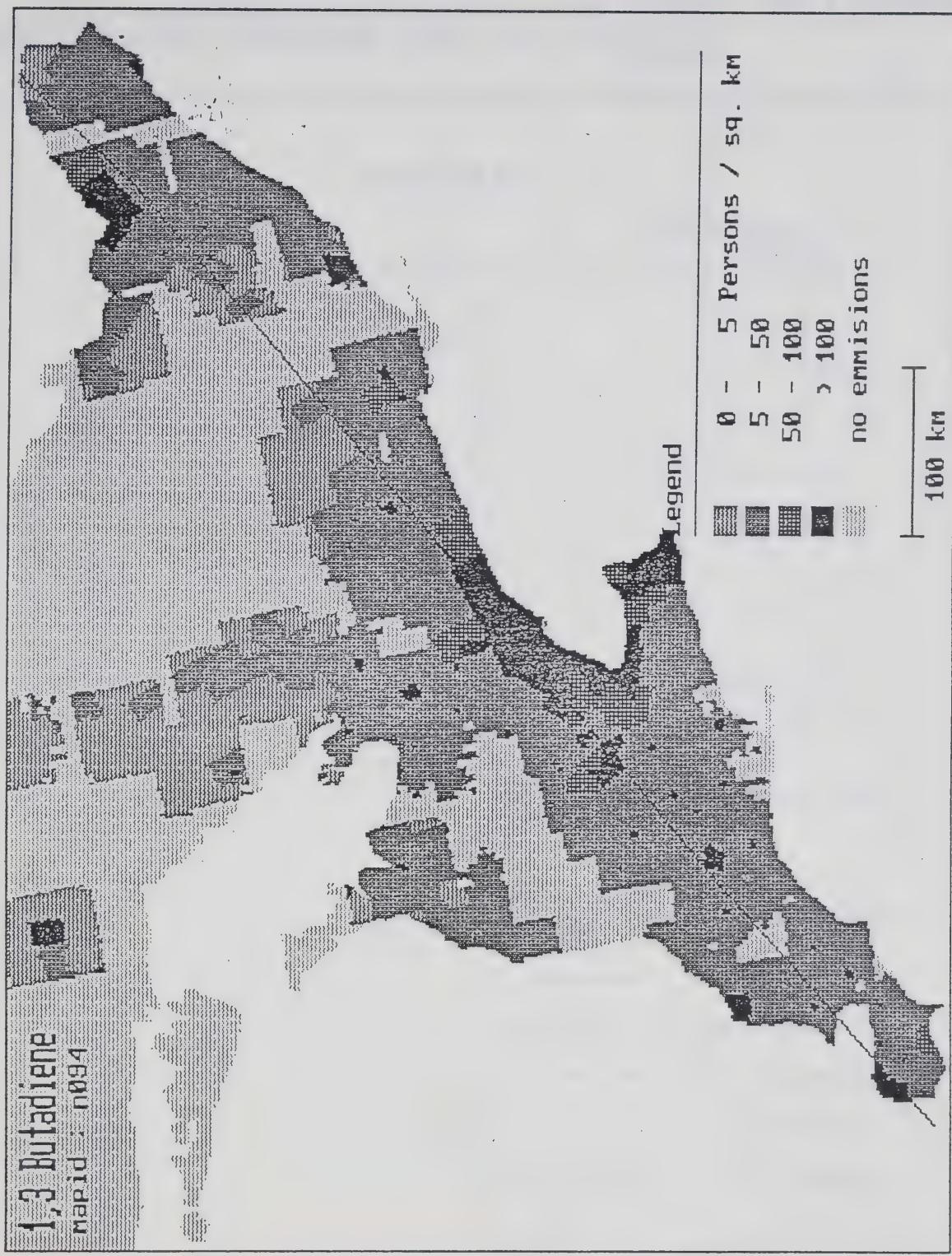
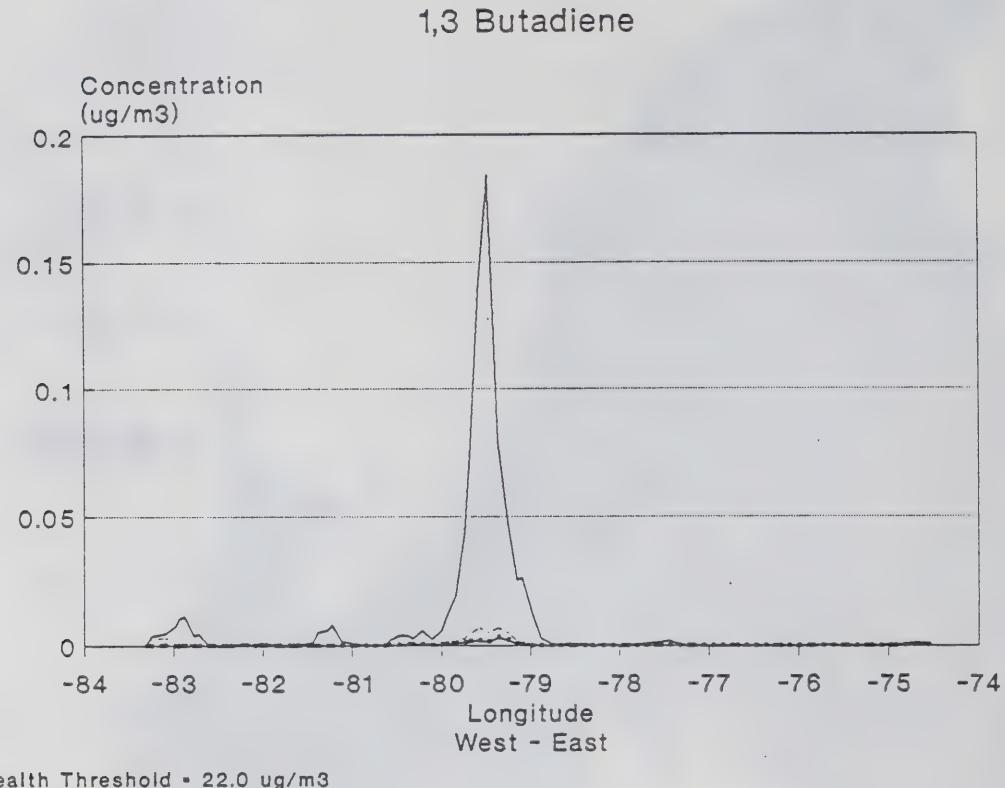


EXHIBIT I.10: PROFILE OF 1,3 BUTADIENE CONCENTRATION DUE TO REGULATION 308 SOURCE EMISSIONS ACROSS SOUTHERN ONTARIO



Legend

- | | |
|-----------------|---------|
| Existing | — |
| Scenarios A & D | — |
| Scenario B | — |
| Scenario C | · · · · |
| Scenario E | · · · · |

EXHIBIT I.11: AREAS EXPOSED TO 2-BUTANONE FROM REGULATION 308 SOURCE EMISSIONS

I - 11

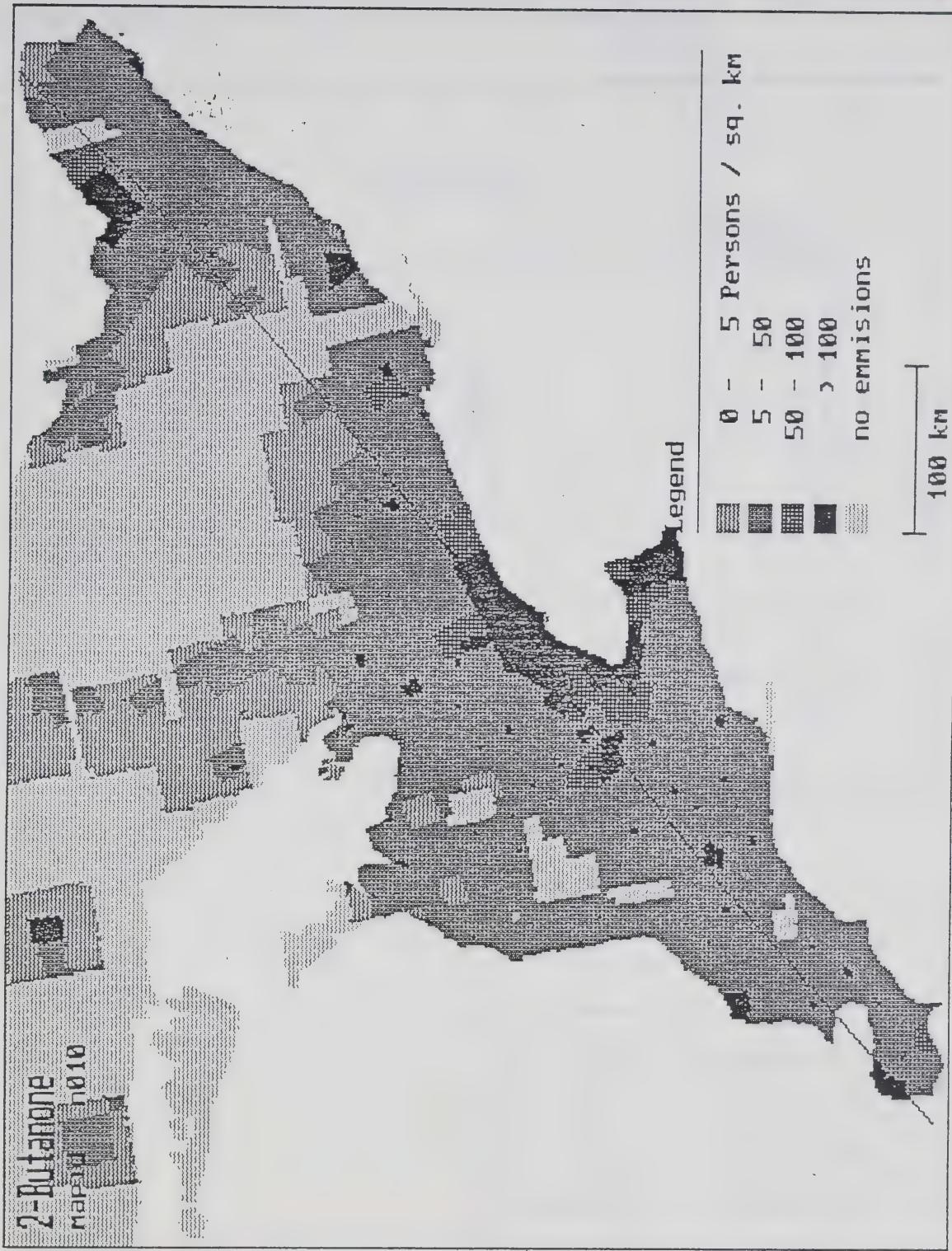
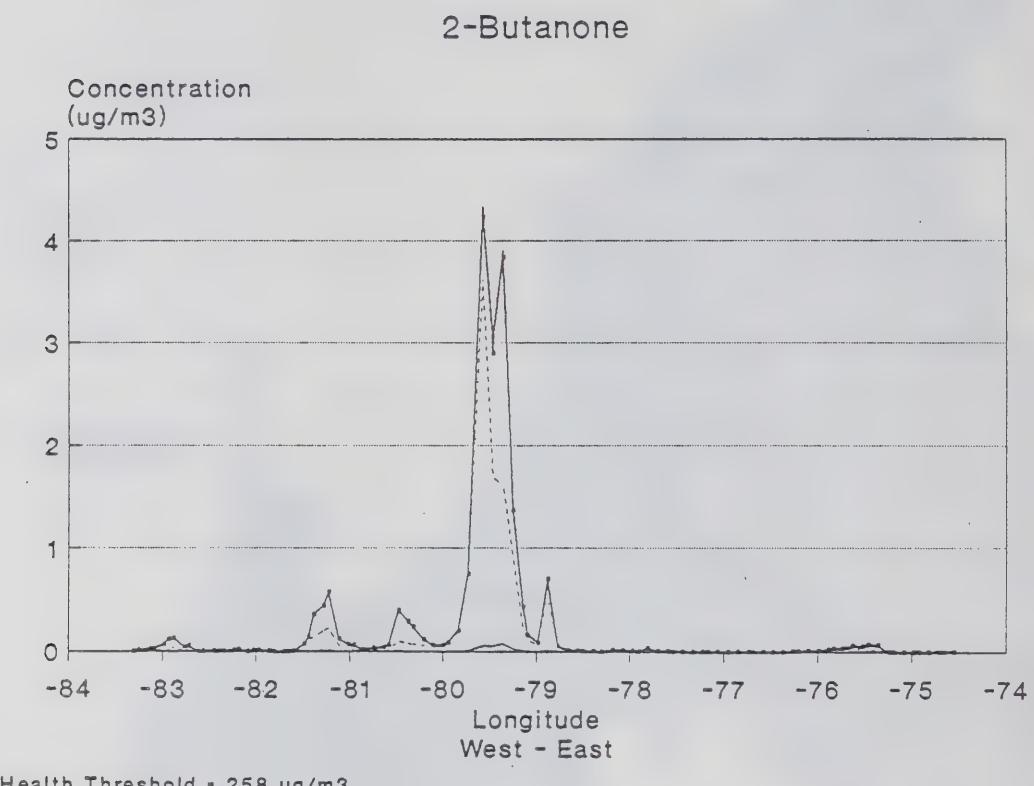


EXHIBIT I.12: PROFILE OF 2-BUTANONE CONCENTRATION DUE TO
REGULATION 308 SOURCE EMISSIONS ACROSS SOUTHERN
ONTARIO



Legend

- | | |
|-----------------|-----------|
| Existing | — |
| Scenarios A & D | — |
| Scenario B | — |
| Scenario C | ----- |
| Scenario E | · · · · · |
-

EXHIBIT I.13: AREAS EXPOSED TO BUTYL ACRYLATE FROM REGULATION 308 SOURCE EMISSIONS

Butyl Acrylate
Rapid : n011

I - 13

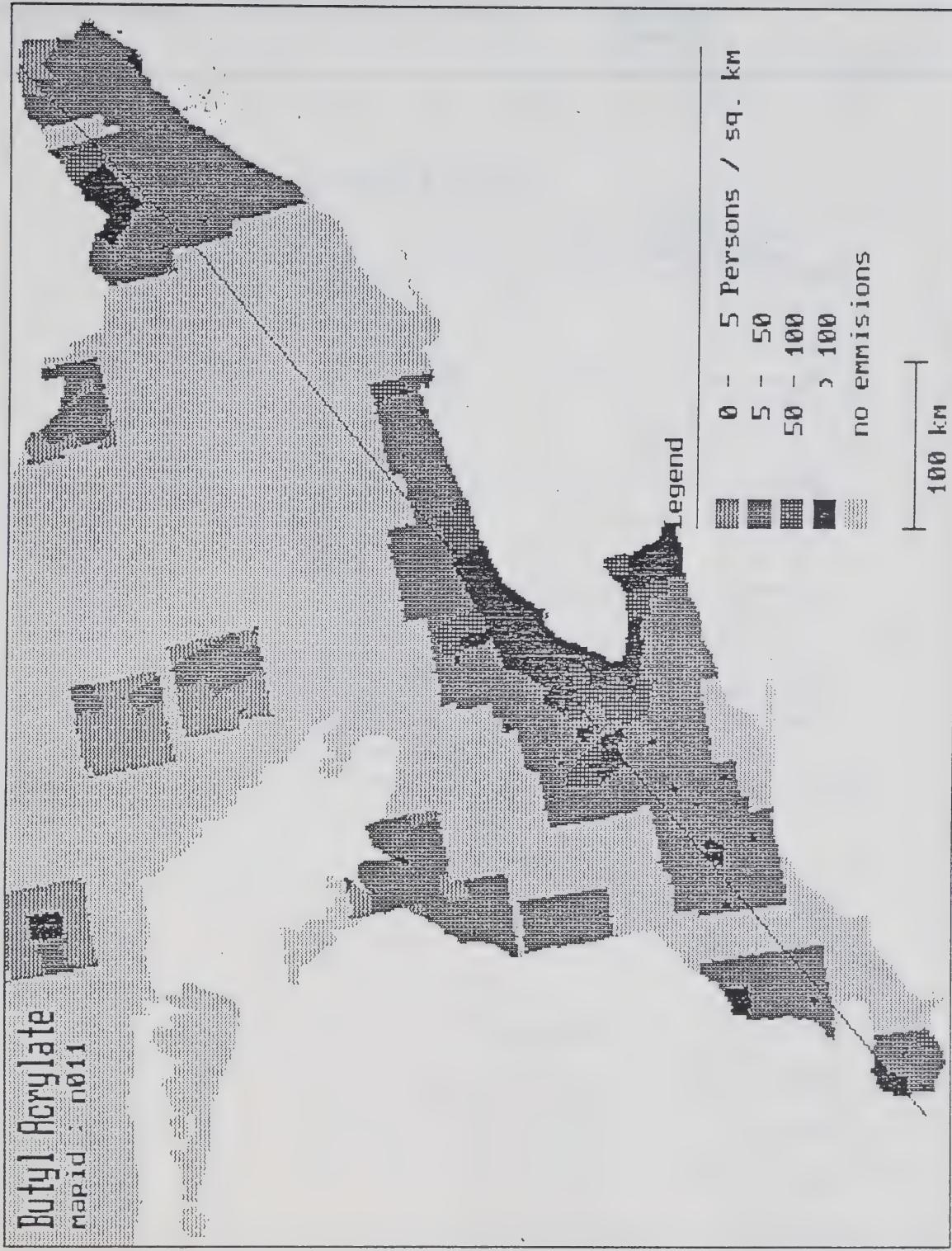
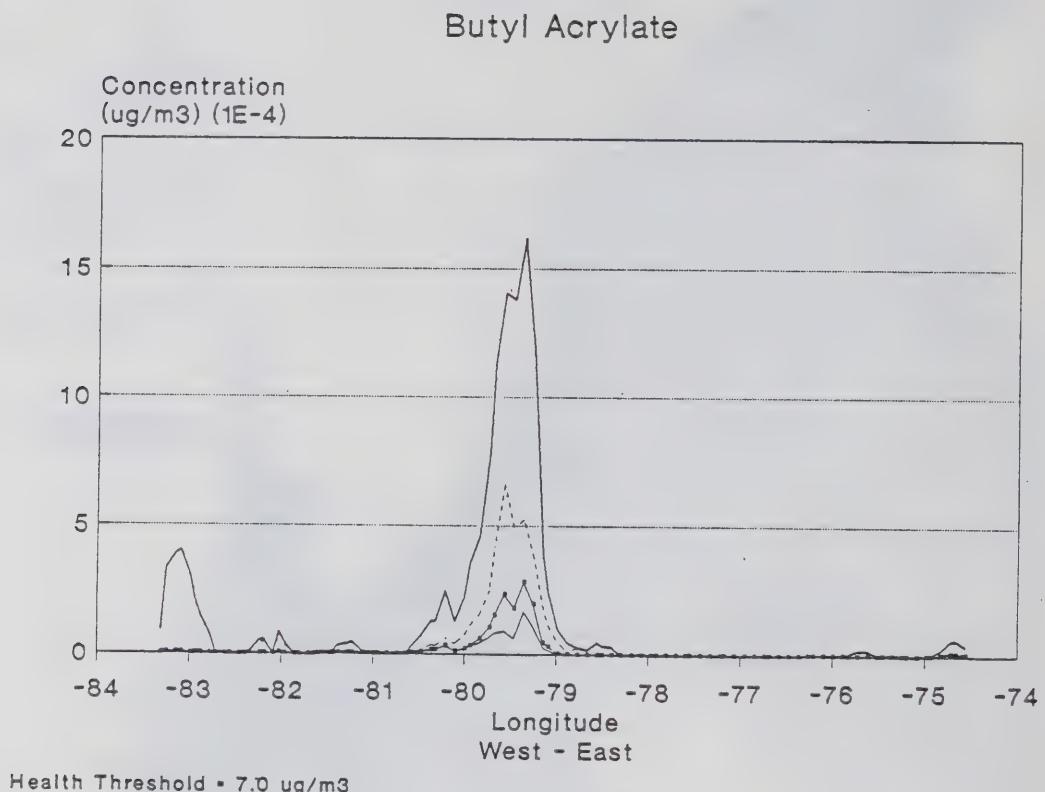


EXHIBIT I.14: PROFILE OF BUTYL ACRYLATE CONCENTRATION DUE TO REGULATION 308 SOURCE EMISSIONS ACROSS SOUTHERN ONTARIO



Legend

- | | |
|-----------------|-------|
| Existing | — |
| Scenarios A & D | — |
| Scenario B | — |
| Scenario C | ..... |
| Scenario E | ..... |

EXHIBIT I.15: AREAS EXPOSED TO CADMIUM FROM REGULATION 308 SOURCE EMISSIONS

I - 15

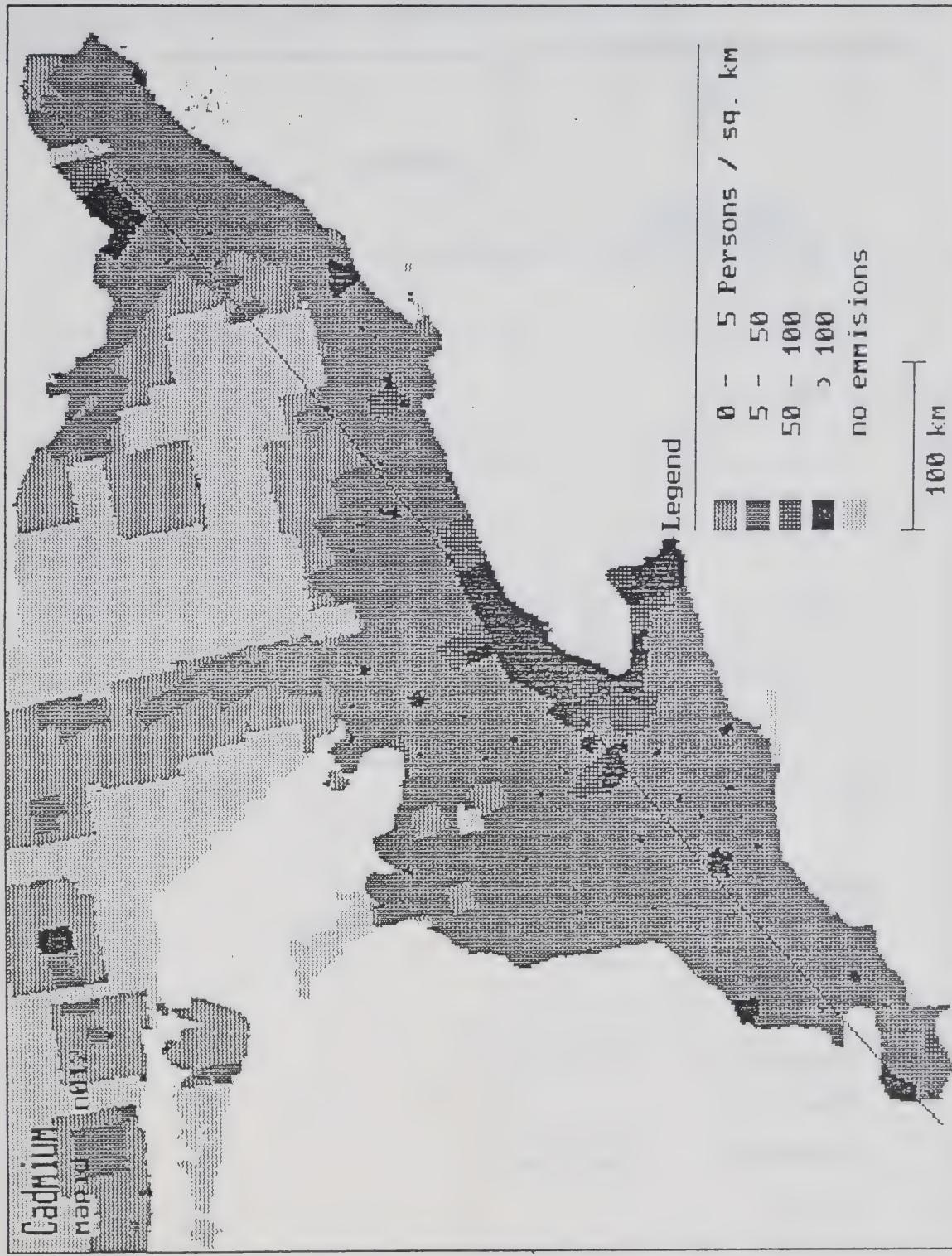
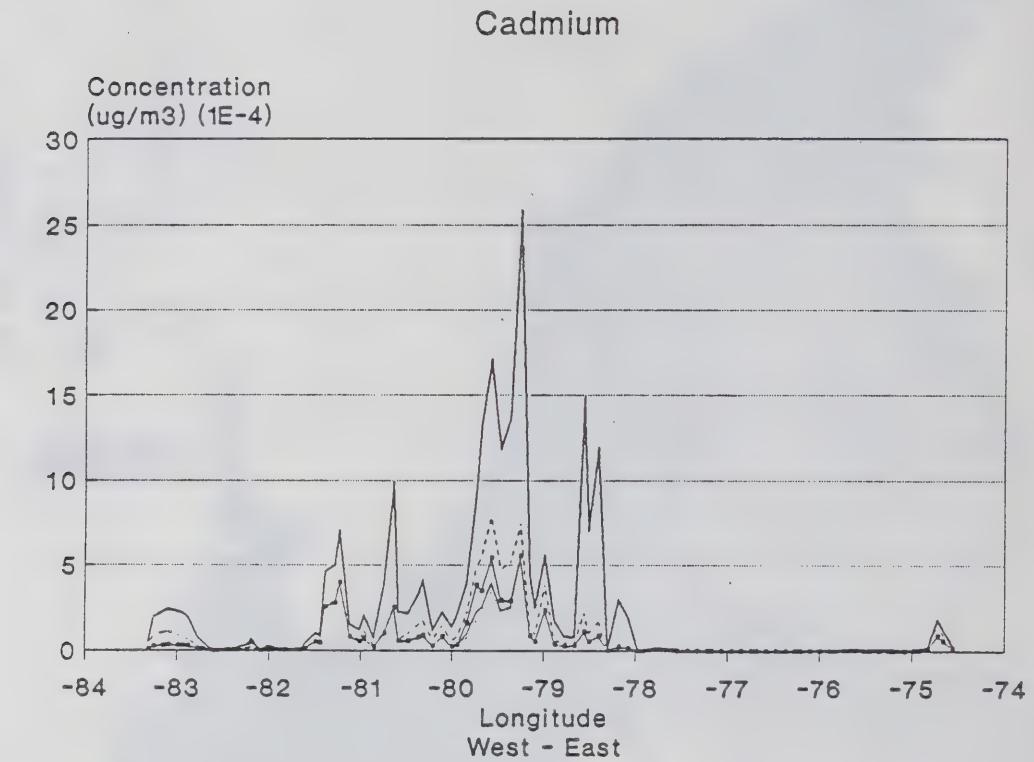


EXHIBIT I.16: PROFILE OF CADMIUM CONCENTRATION DUE TO REGULATION
308 SOURCE EMISSIONS ACROSS SOUTHERN ONTARIO



Legend

- | | |
|-----------------|-------|
| Existing | — |
| Scenarios A & D | — |
| Scenario B | — |
| Scenario C | ..... |
| Scenario E | ..... |

EXHIBIT I.17: AREAS EXPOSED TO CARBON TETRACHLORIDE FROM REGULATION 308 SOURCE EMISSIONS

I - 17

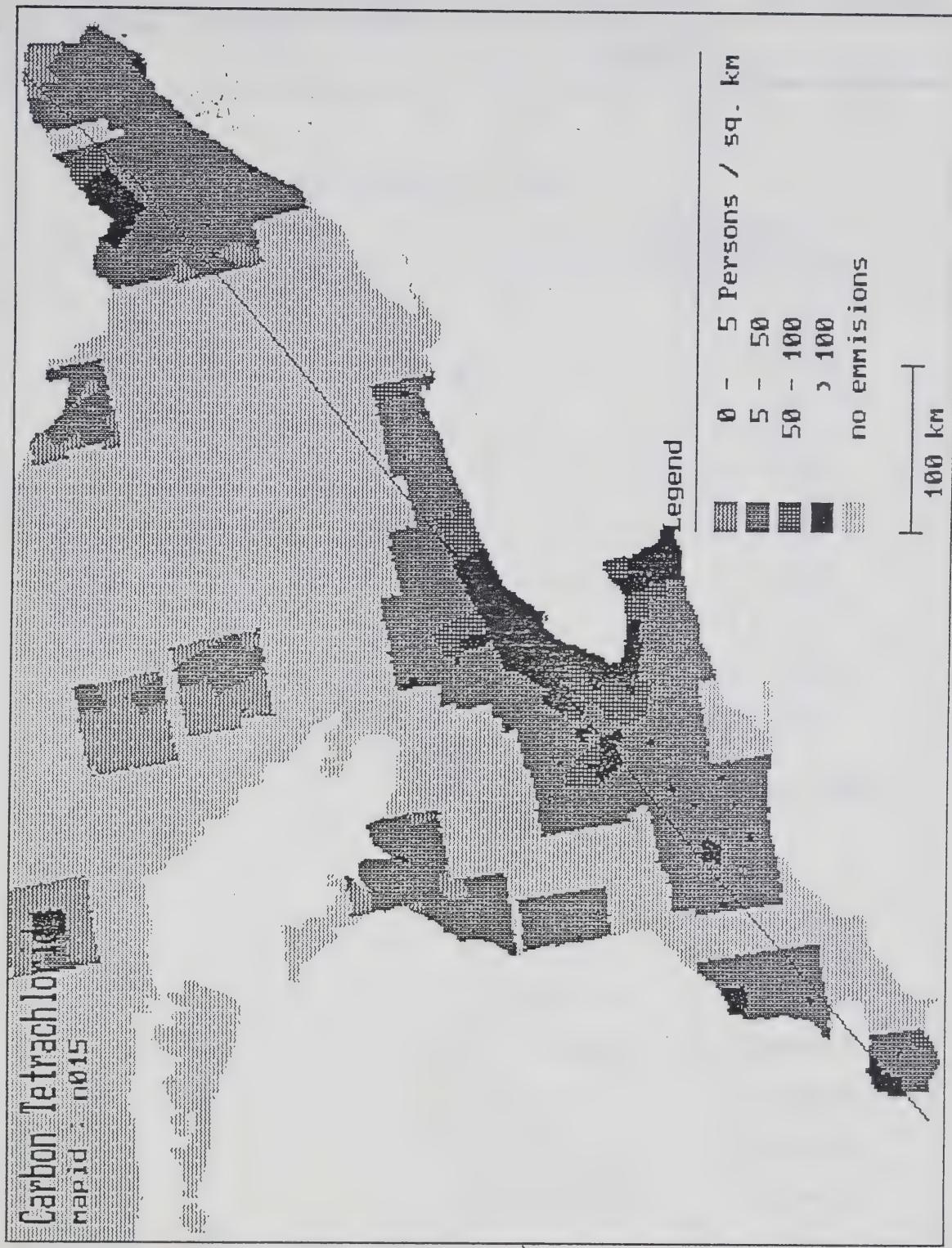
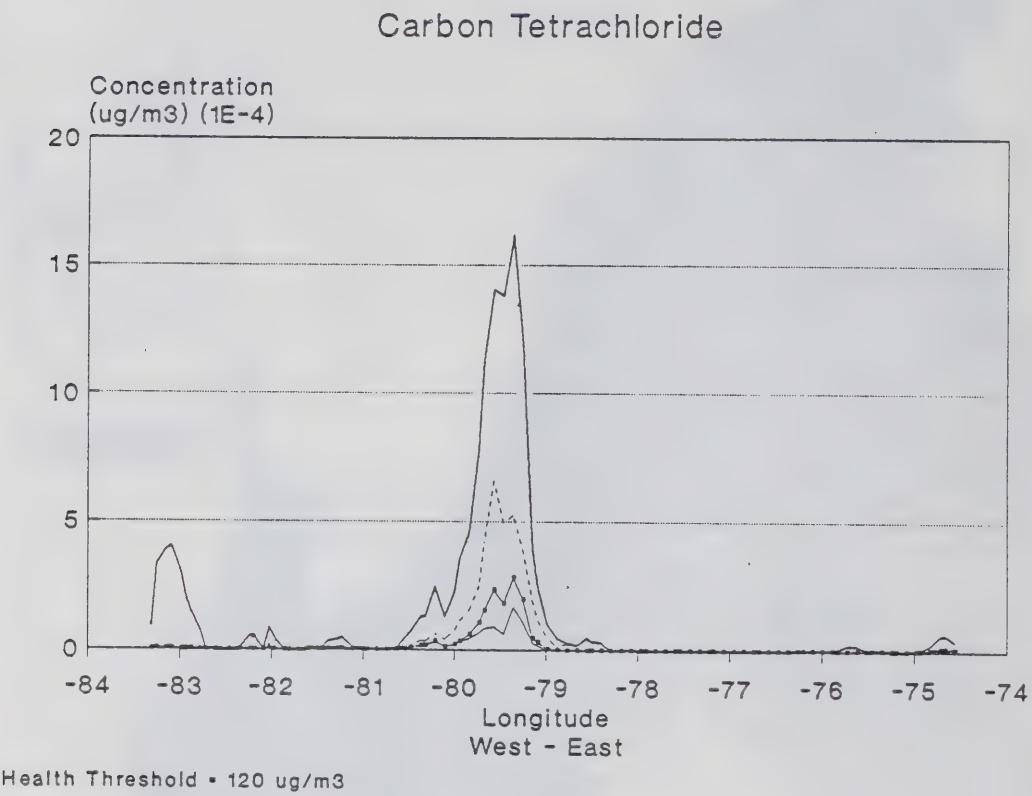


EXHIBIT I.18: PROFILE OF CARBON TETRACHLORIDE CONCENTRATION DUE TO REGULATION 308 SOURCE EMISSIONS ACROSS SOUTHERN ONTARIO



Legend

- | | |
|-----------------|-------|
| Existing | — |
| Scenarios A & D | — |
| Scenario B | — |
| Scenario C | ----- |
| Scenario E | ***** |

EXHIBIT I.19: AREAS EXPOSED TO CDD's FROM REGULATION 308 SOURCE EMISSIONS

I - 19

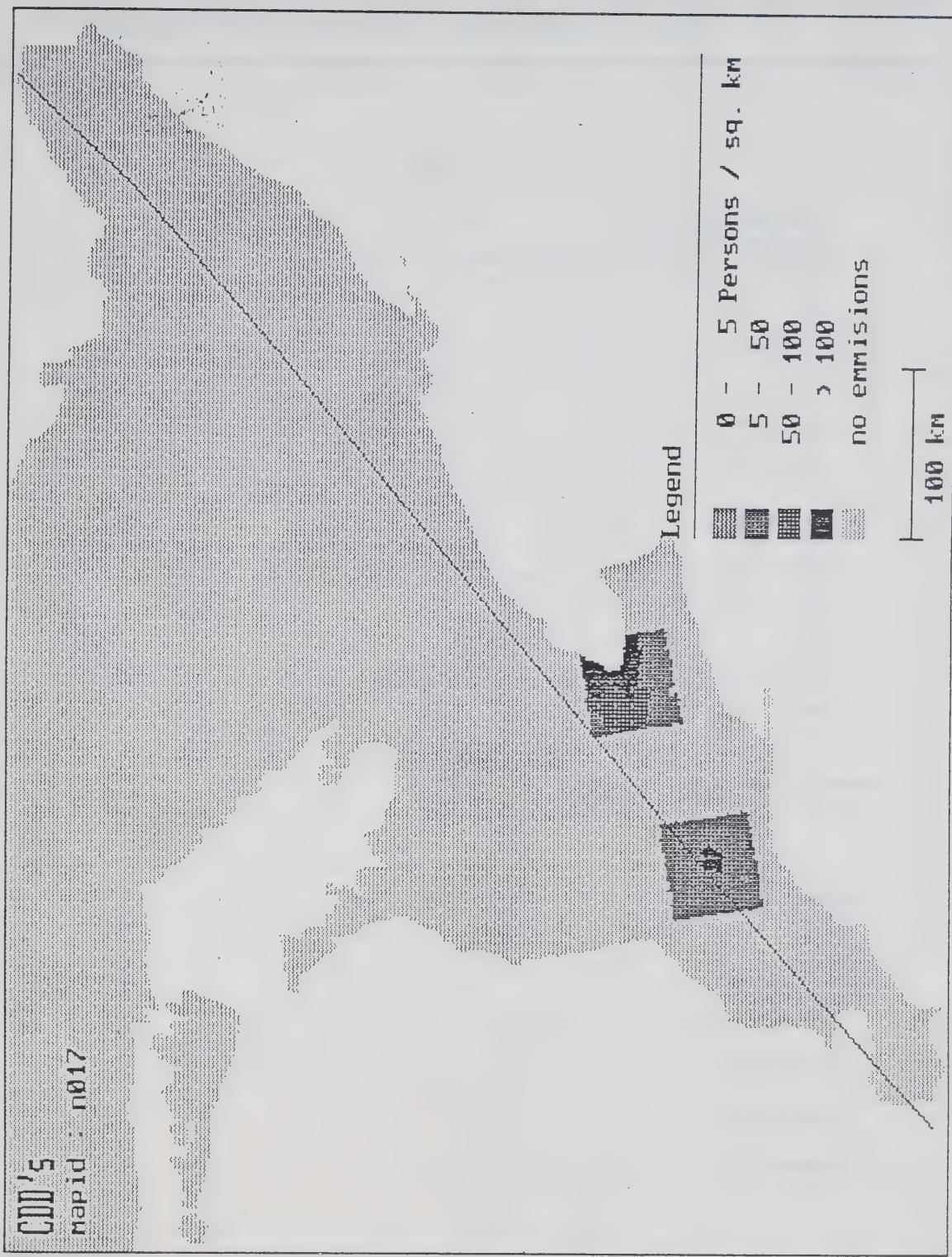
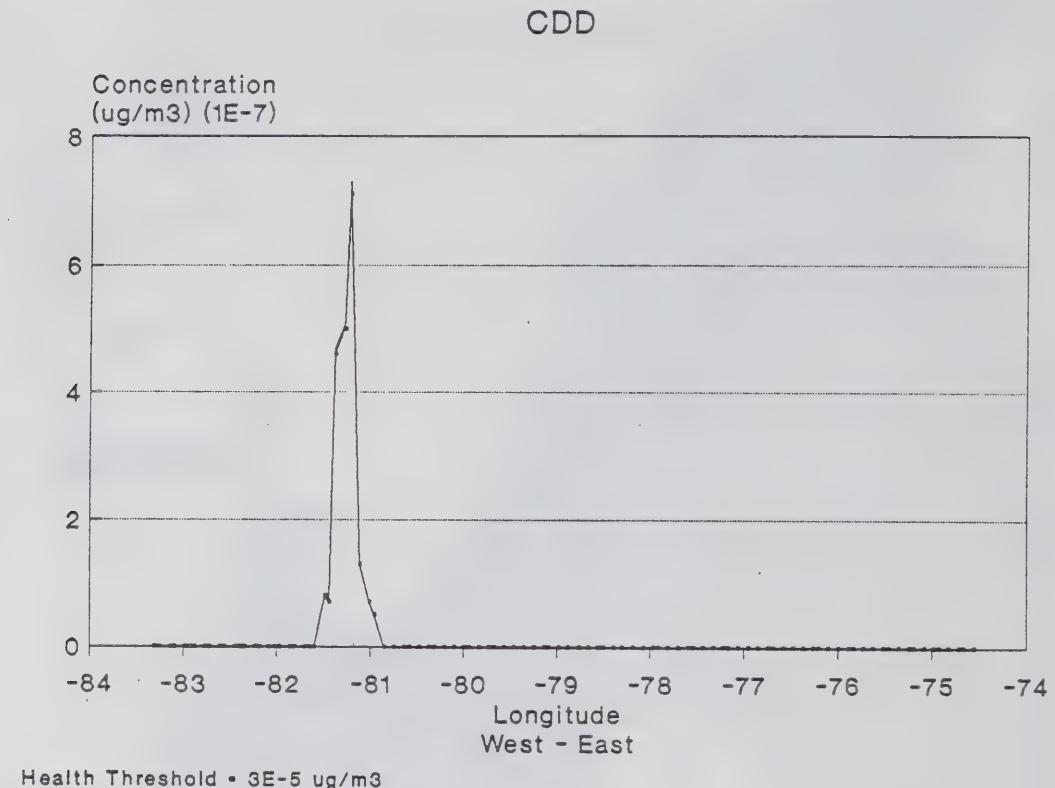


EXHIBIT I.20: PROFILE OF CDD CONCENTRATION DUE TO REGULATION 308
SOURCE EMISSIONS ACROSS SOUTHERN ONTARIO



Legend

- | | |
|-----------------|-------|
| Existing | — |
| Scenarios A & D | — |
| Scenario B | — |
| Scenario C | ----- |
| Scenario E | ..... |

EXHIBIT I.21: AREAS EXPOSED TO CDF'S FROM REGULATION 308 SOURCE EMISSIONS

I - 21

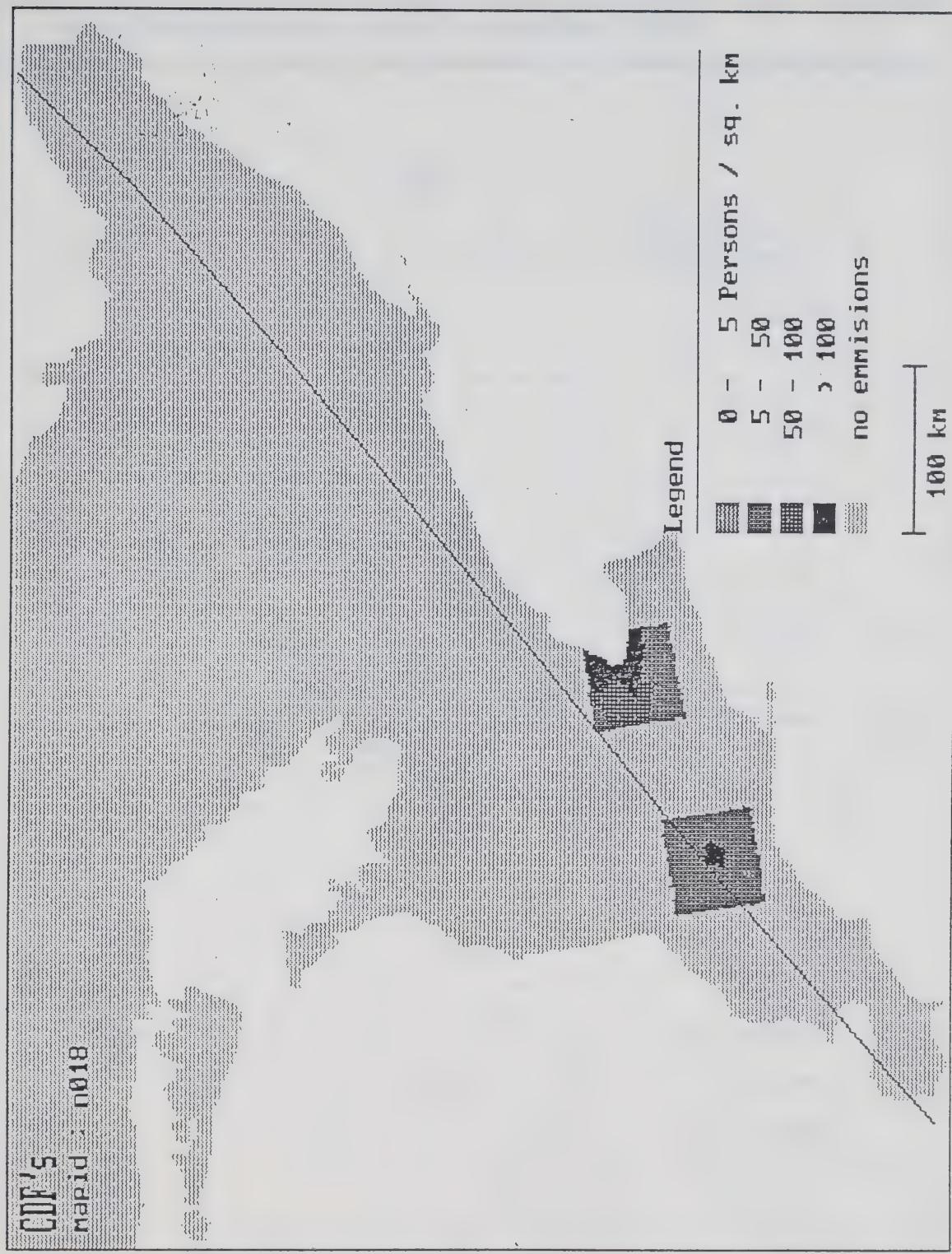
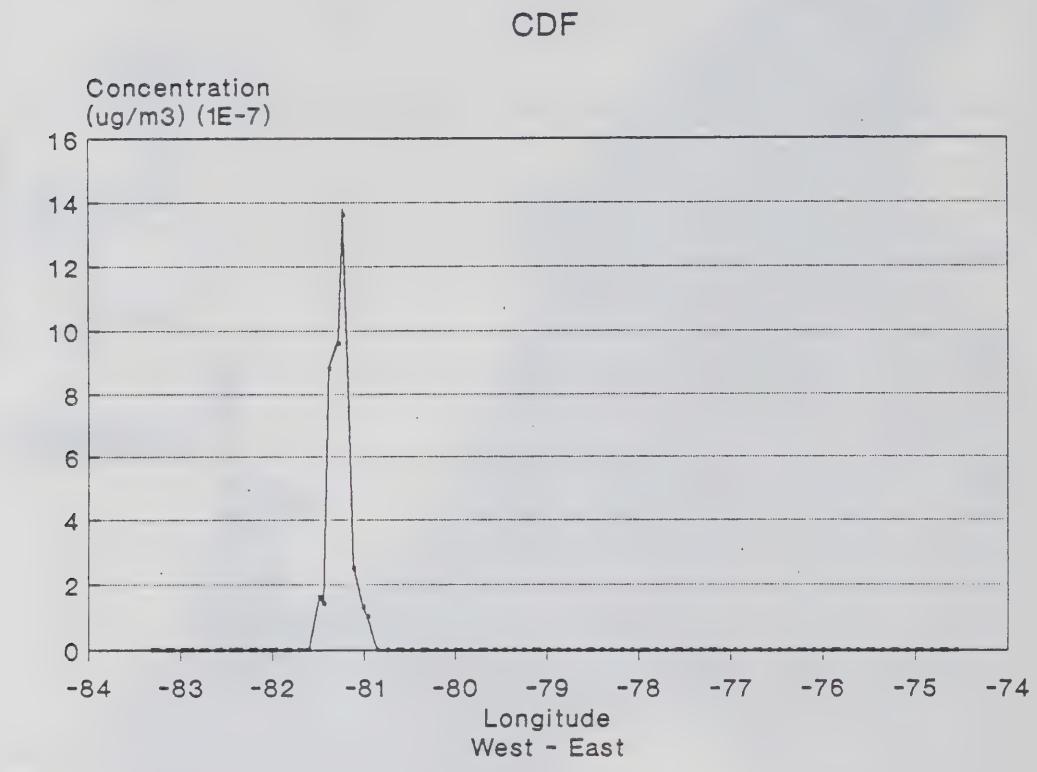


EXHIBIT I.22: PROFILE OF CDF CONCENTRATION DUE TO REGULATION 308
SOURCE EMISSIONS ACROSS SOUTHERN ONTARIO



Legend

Existing	—
Scenarios A & D	—
Scenario B	—
Scenario C	---
Scenario E	----

EXHIBIT I.23: AREAS EXPOSED TO CHLORINE FROM REGULATION 308 SOURCE EMISSIONS

I - 23

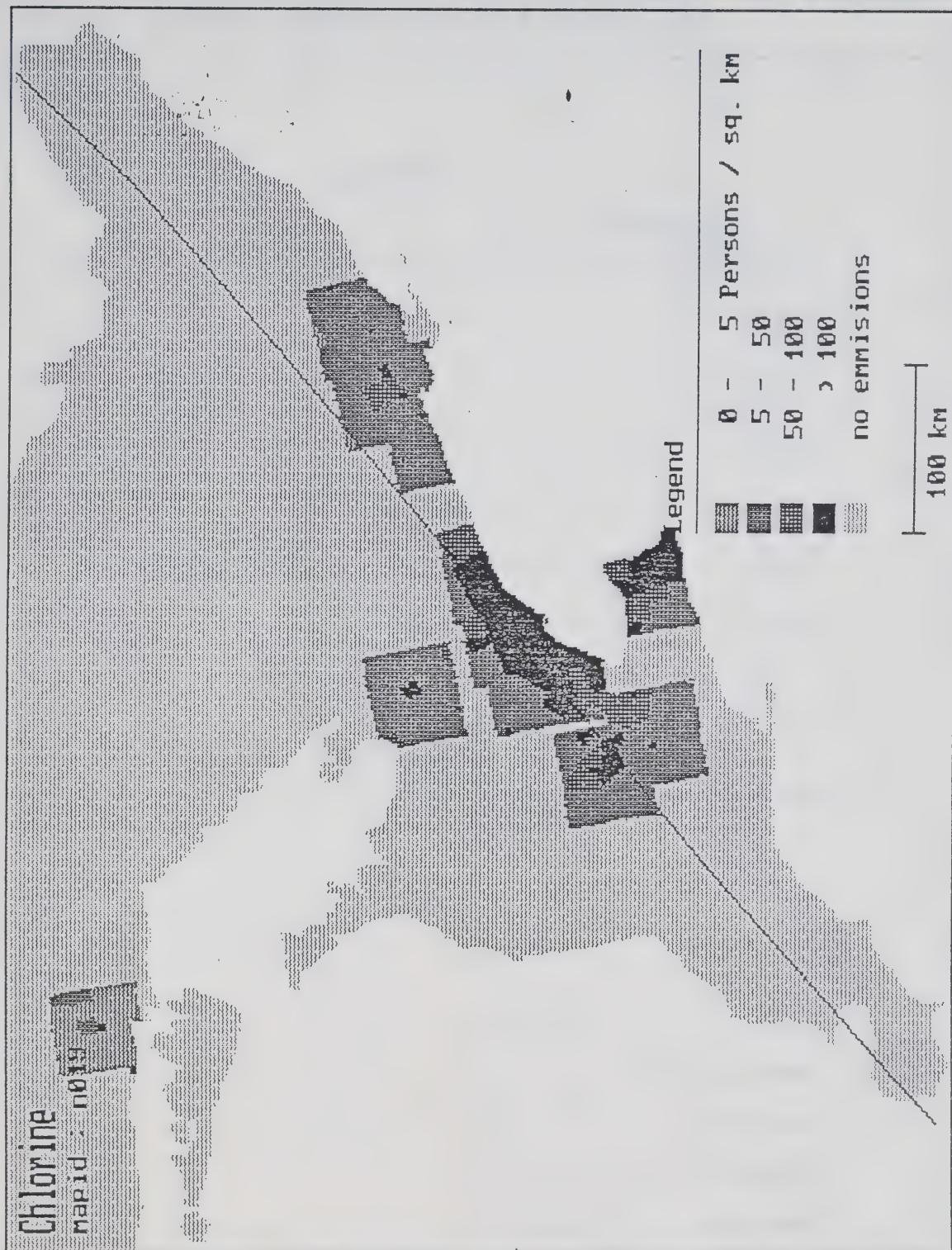
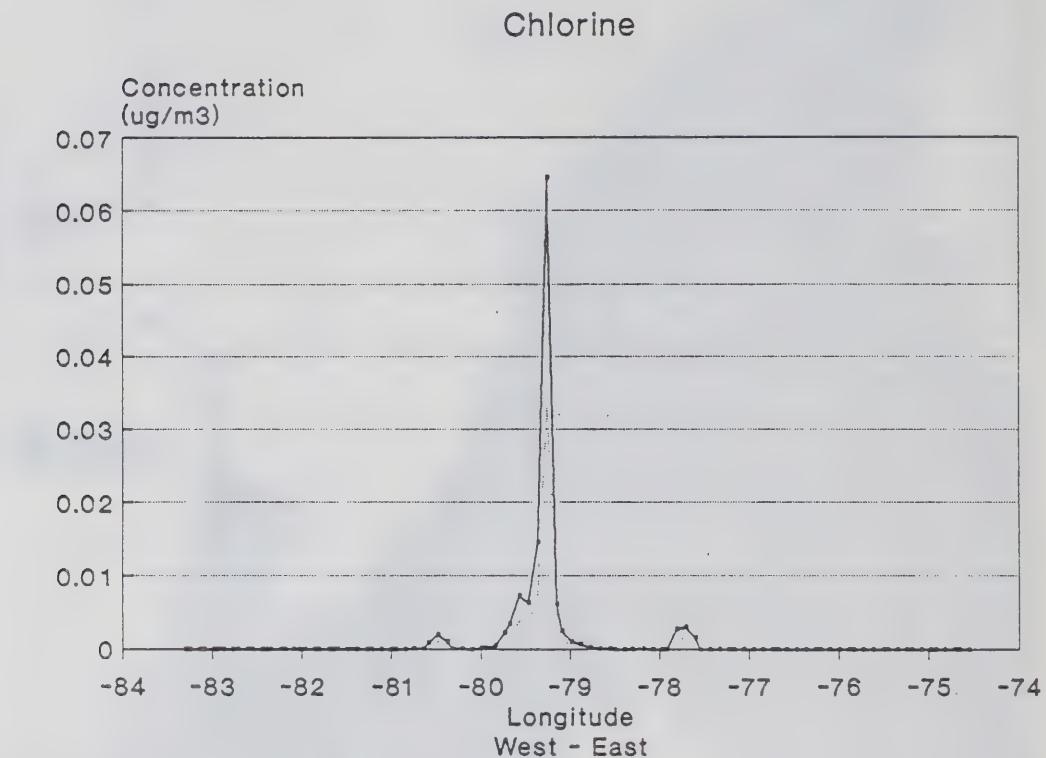


EXHIBIT I.24: PROFILE OF CHLORINE CONCENTRATION DUE TO REGULATION
308 SOURCE EMISSIONS ACROSS SOUTHERN ONTARIO



Health Threshold = 30 $\mu\text{g}/\text{m}^3$

Legend

- | | |
|-----------------|-------|
| Existing | _____ |
| Scenarios A & D | _____ |
| Scenario B | _____ |
| Scenario C | ----- |
| Scenario E | ***** |

EXHIBIT I.25: AREAS EXPOSED TO CHLORINE DIOXIDE FROM REGULATION 308 SOURCE EMISSIONS

I - 25

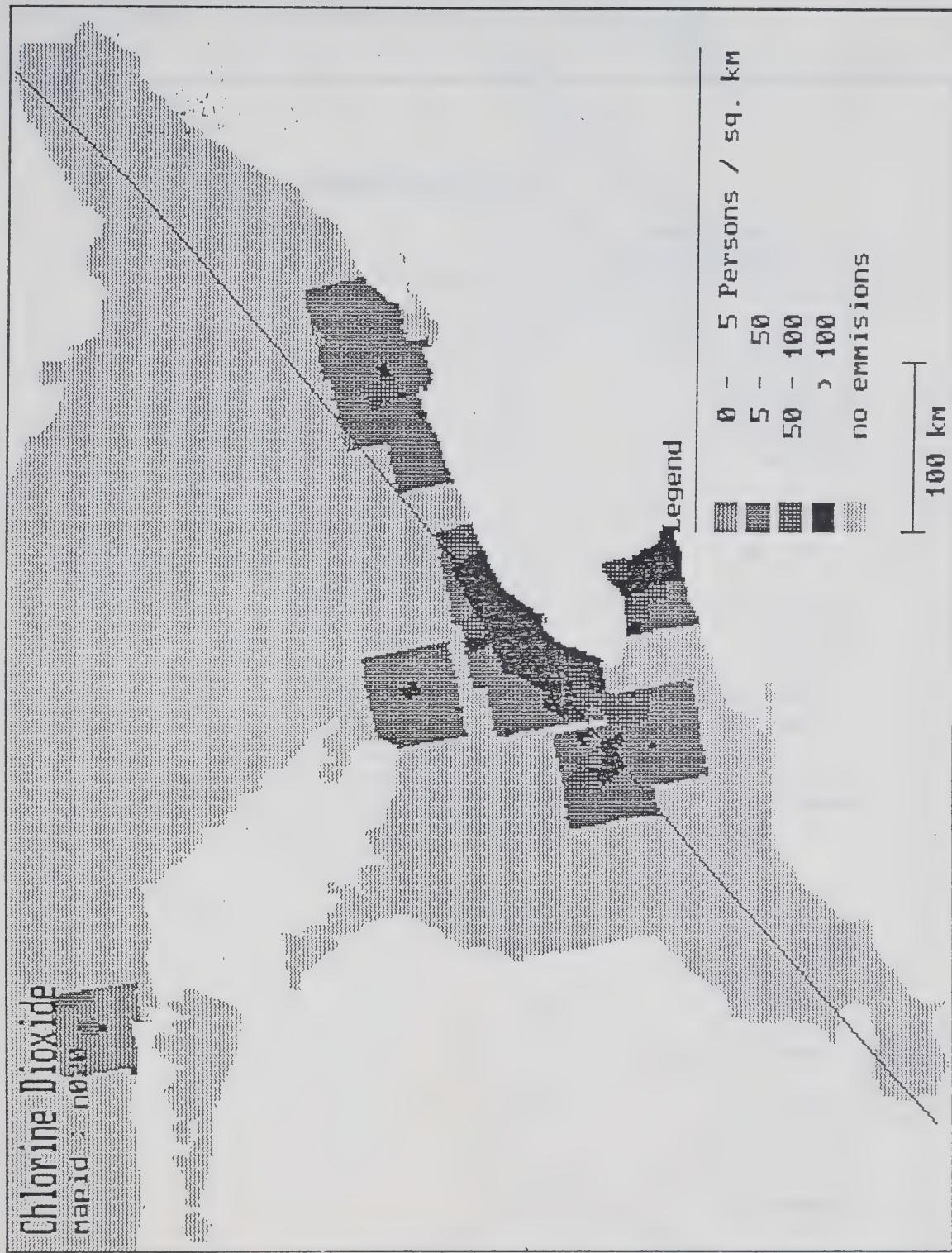
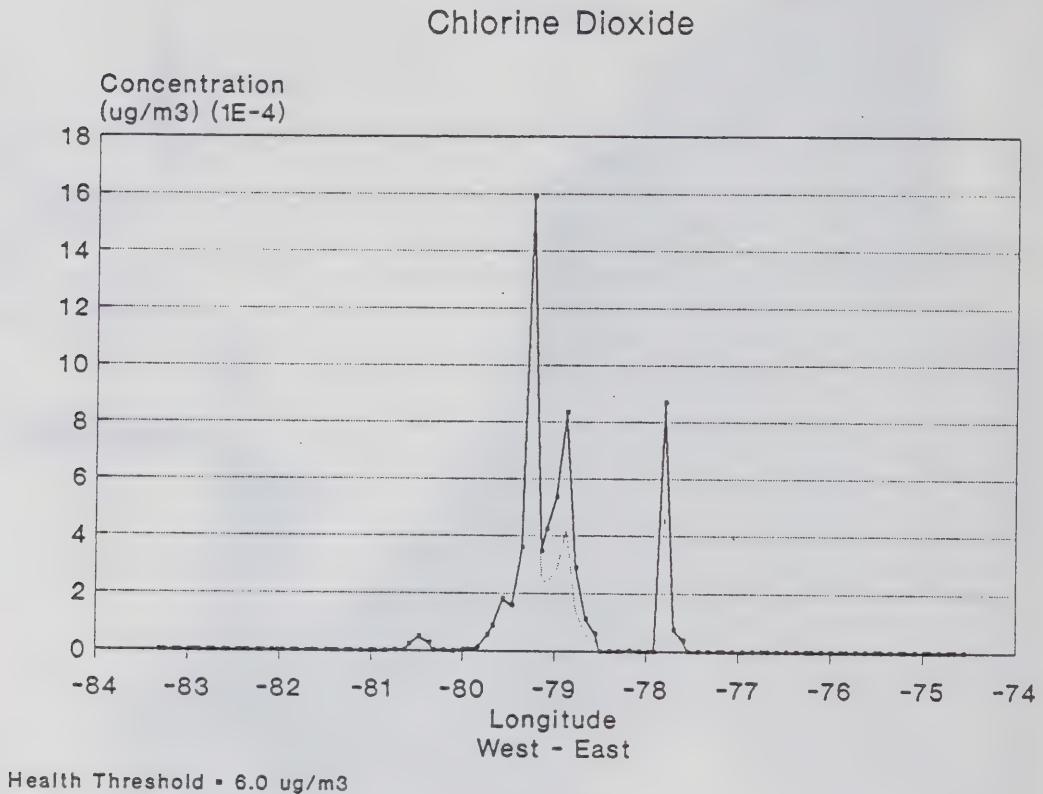


EXHIBIT I.26: PROFILE OF CHLORINE DIOXIDE CONCENTRATION DUE TO
REGULATION 308 SOURCE EMISSIONS ACROSS SOUTHERN
ONTARIO



Legend

- | | |
|-----------------|--------|
| Existing | — |
| Scenarios A & D | --- |
| Scenario B | —·— |
| Scenario C | ·----- |
| Scenario E | ······ |

EXHIBIT I.27: AREAS EXPOSED TO CHLOROFORM FROM REGULATION 308 SOURCE EMISSIONS

I - 27

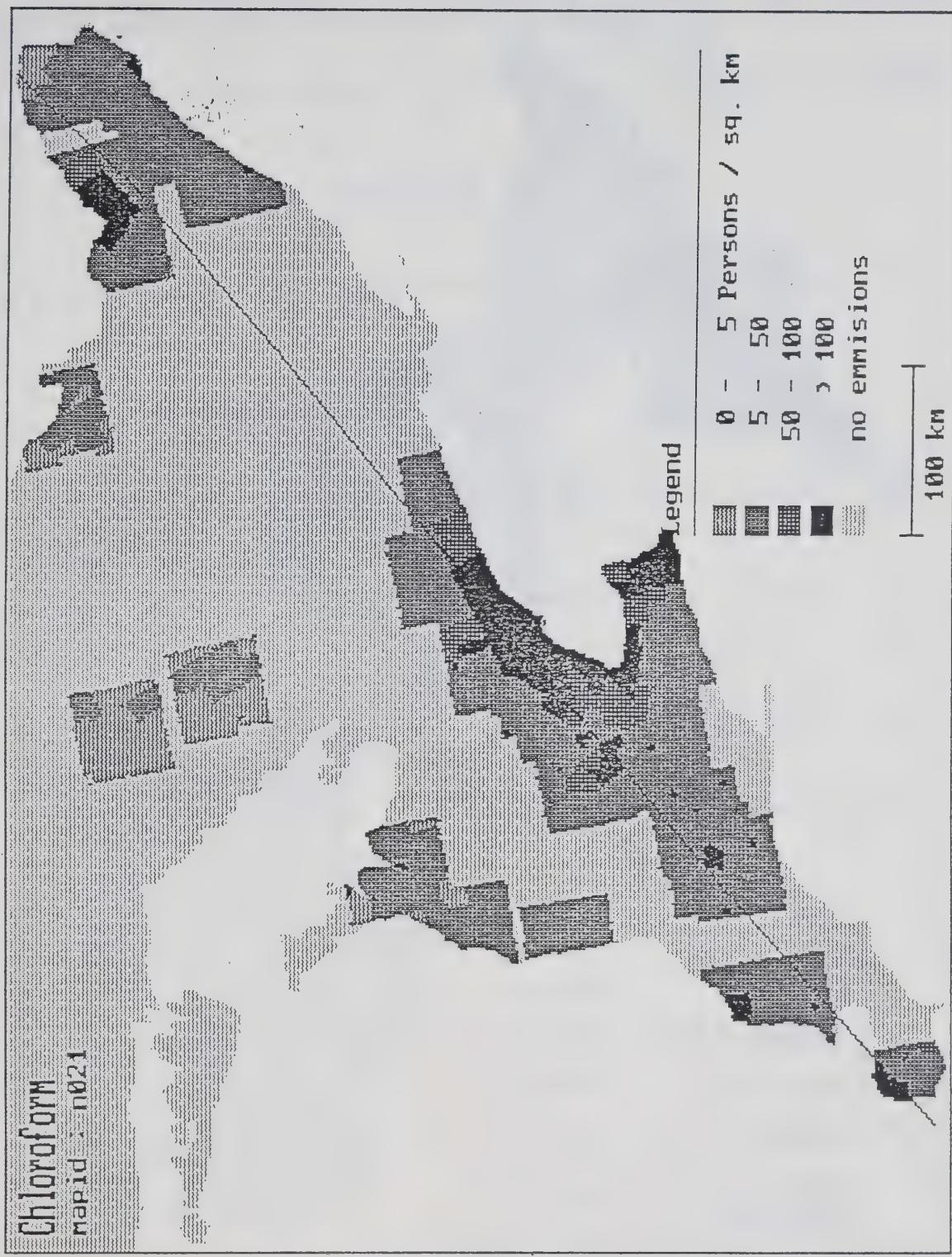
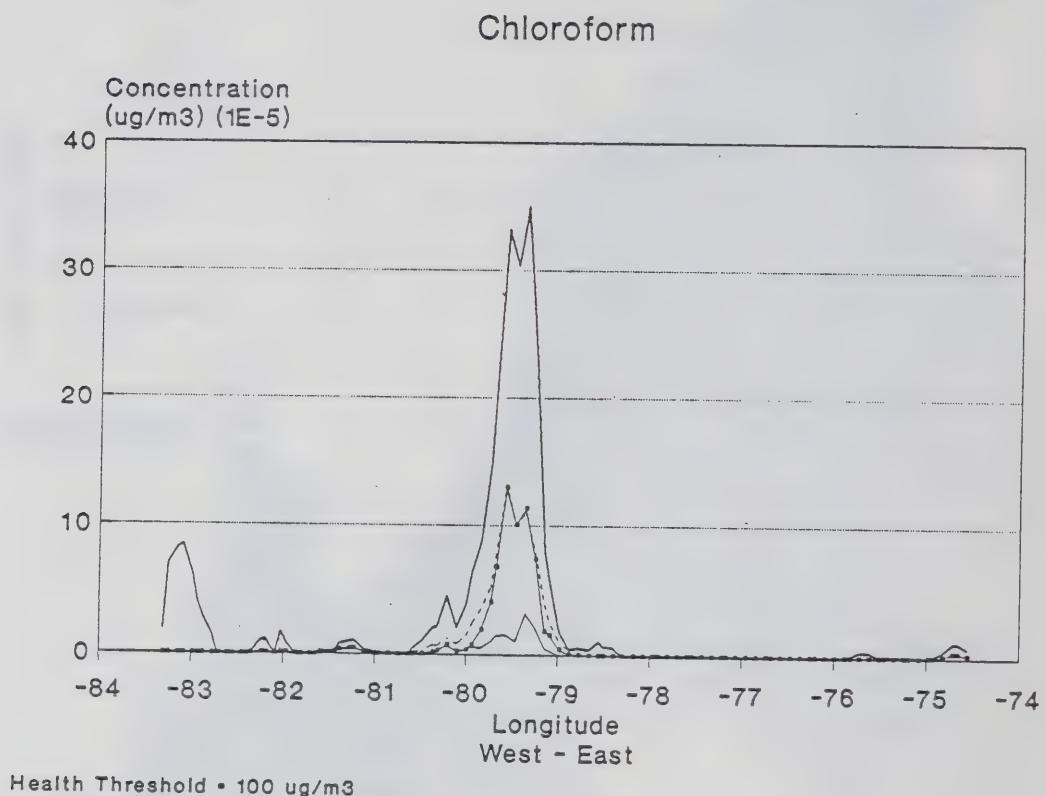


EXHIBIT I.28: PROFILE OF CHLOROFORM CONCENTRATION DUE TO
REGULATION 308 SOURCE EMISSIONS ACROSS SOUTHERN
ONTARIO



Legend

- | | |
|-----------------|-------|
| Existing | — |
| Scenarios A & D | — |
| Scenario B | — |
| Scenario C | ----- |
| Scenario E | ***** |

EXHIBIT I.29: AREAS EXPOSED TO CHROMIUM FROM REGULATION 308 SOURCE EMISSIONS

I - 29

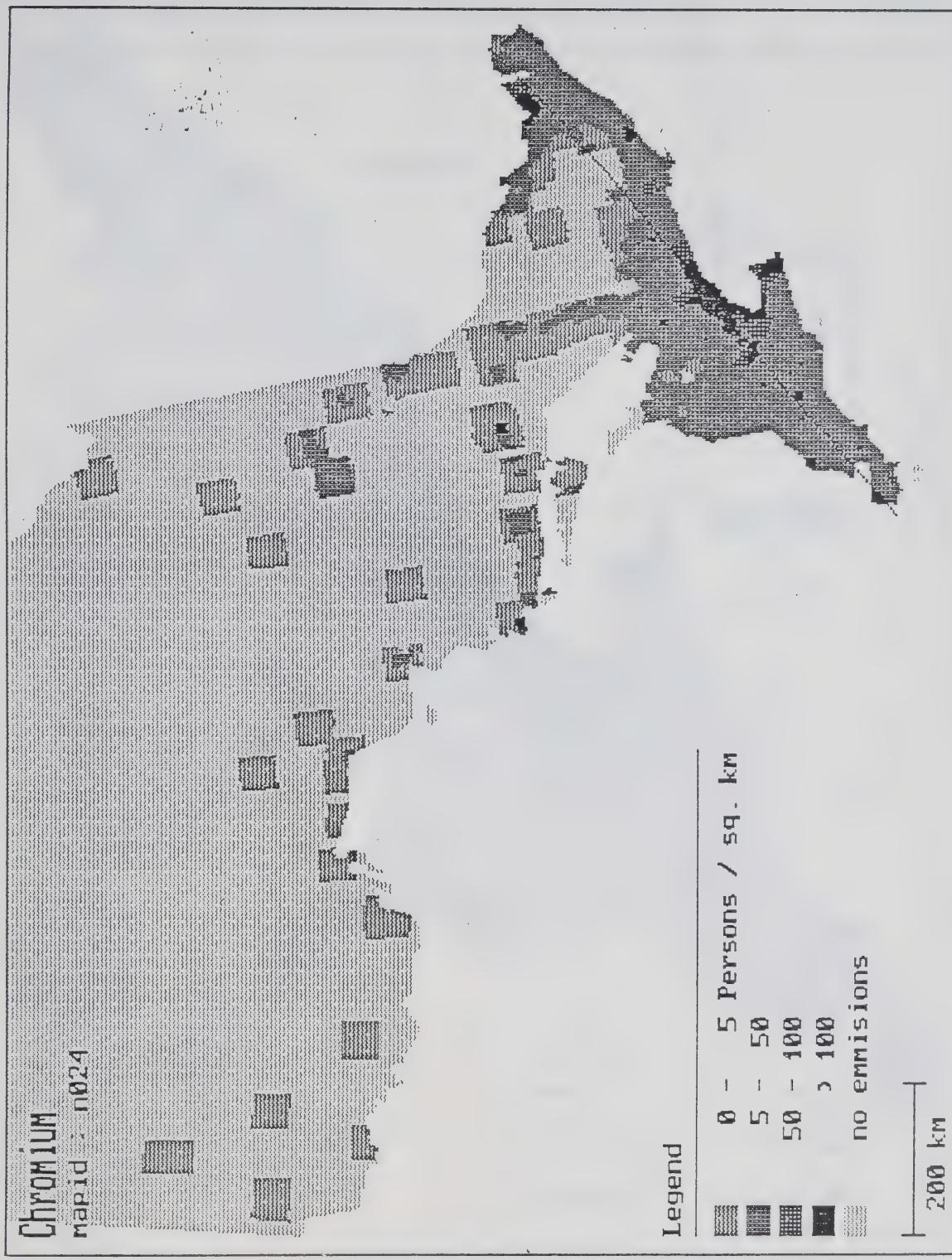
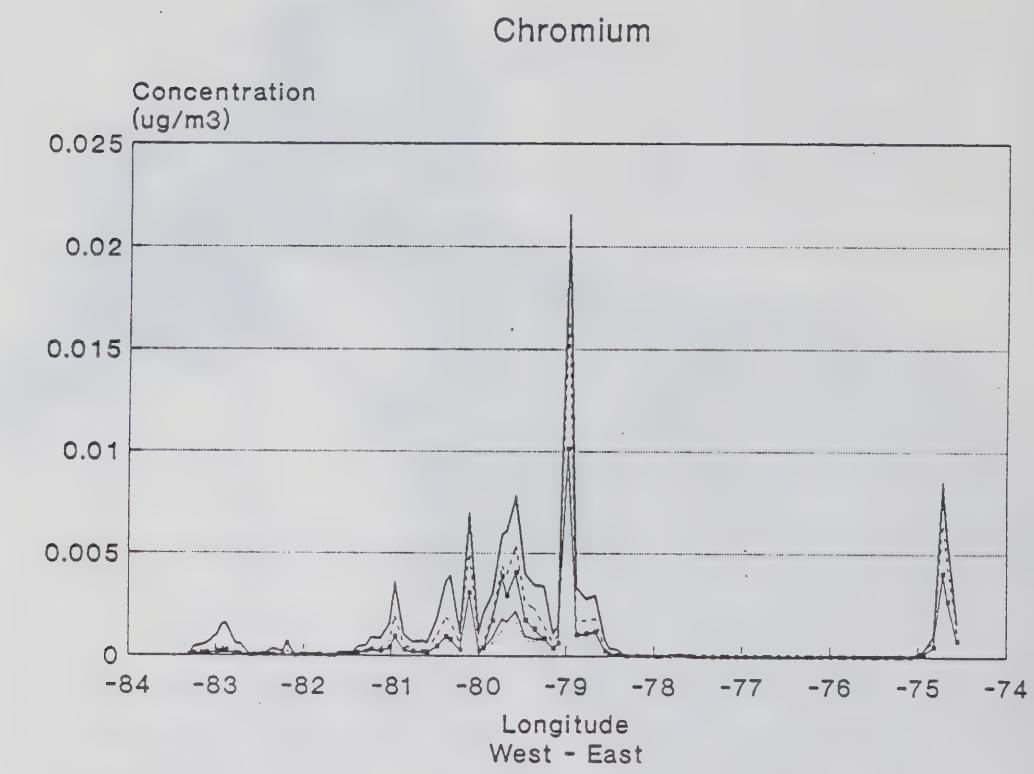


EXHIBIT I.30: PROFILE OF CHROMIUM CONCENTRATION DUE TO REGULATION
308 SOURCE EMISSIONS ACROSS SOUTHERN ONTARIO



Legend

- | | |
|-----------------|-------|
| Existing | — |
| Scenarios A & D | — |
| Scenario B | — |
| Scenario C | ----- |
| Scenario E | ..... |

EXHIBIT I.31: AREAS EXPOSED TO EPICHLOROHYDRIN FROM REGULATION 308 SOURCE EMISSIONS

H - 31

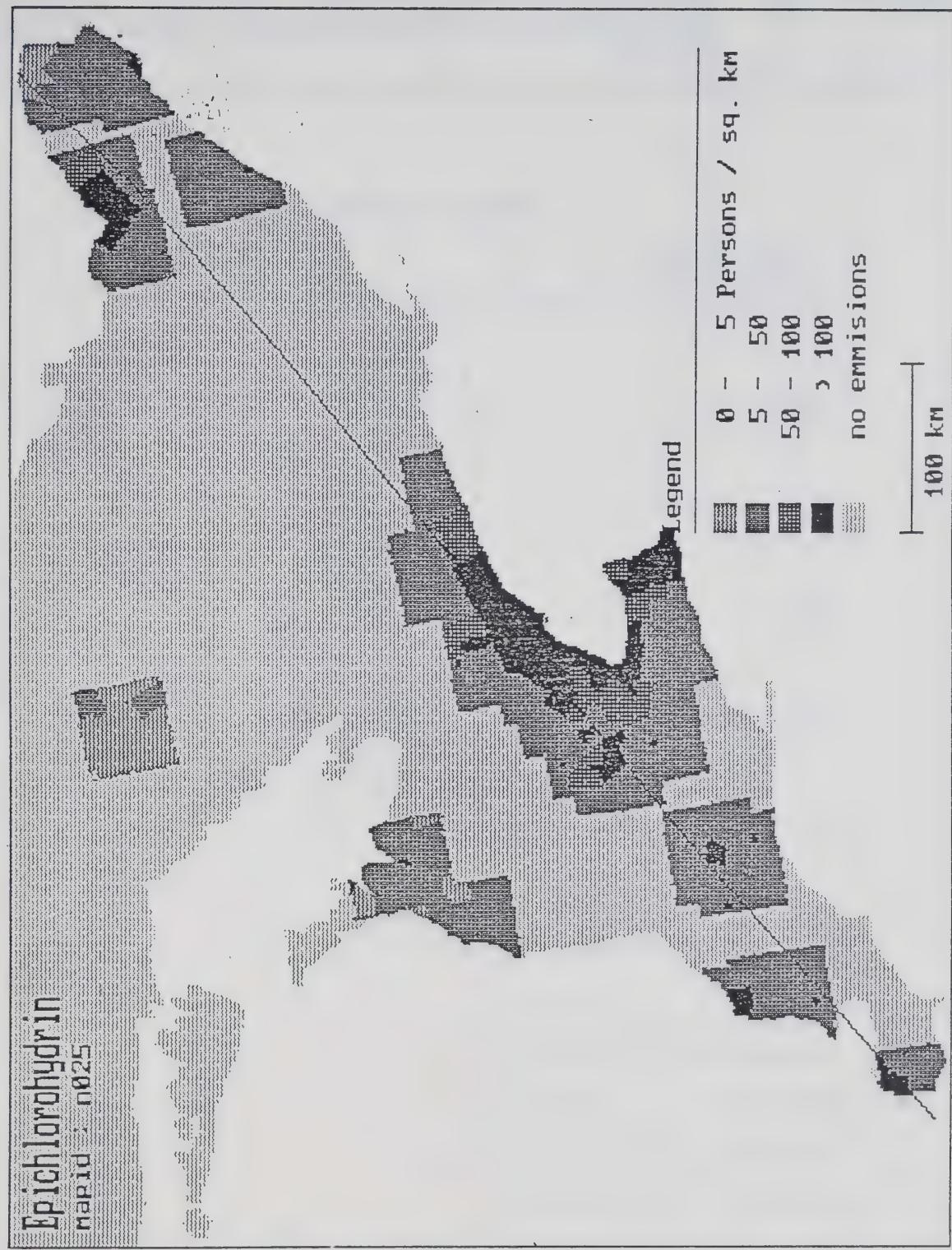


EXHIBIT I.32: PROFILE OF EPICHLOROHYDRIN CONCENTRATION DUE TO REGULATION 308 SOURCE EMISSIONS ACROSS SOUTHERN ONTARIO

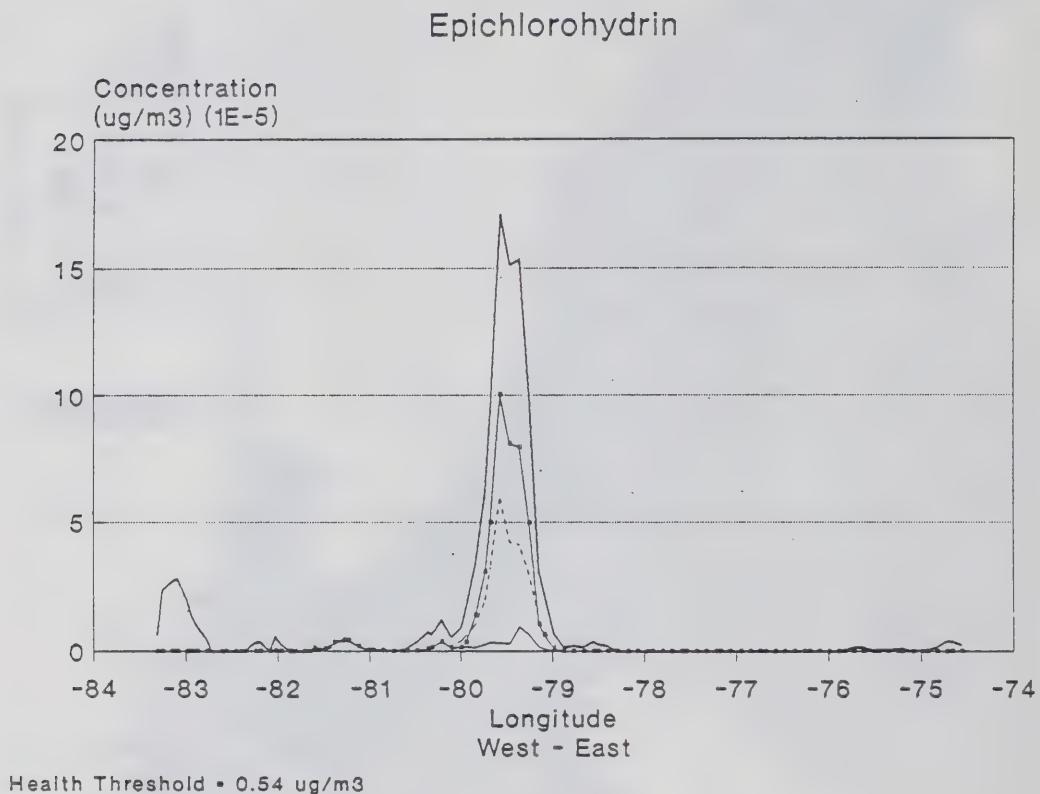


EXHIBIT I. 33: AREAS EXPOSED TO ETHYL BENZENE FROM REGULATION 308 SOURCE EMISSIONS

H - 33

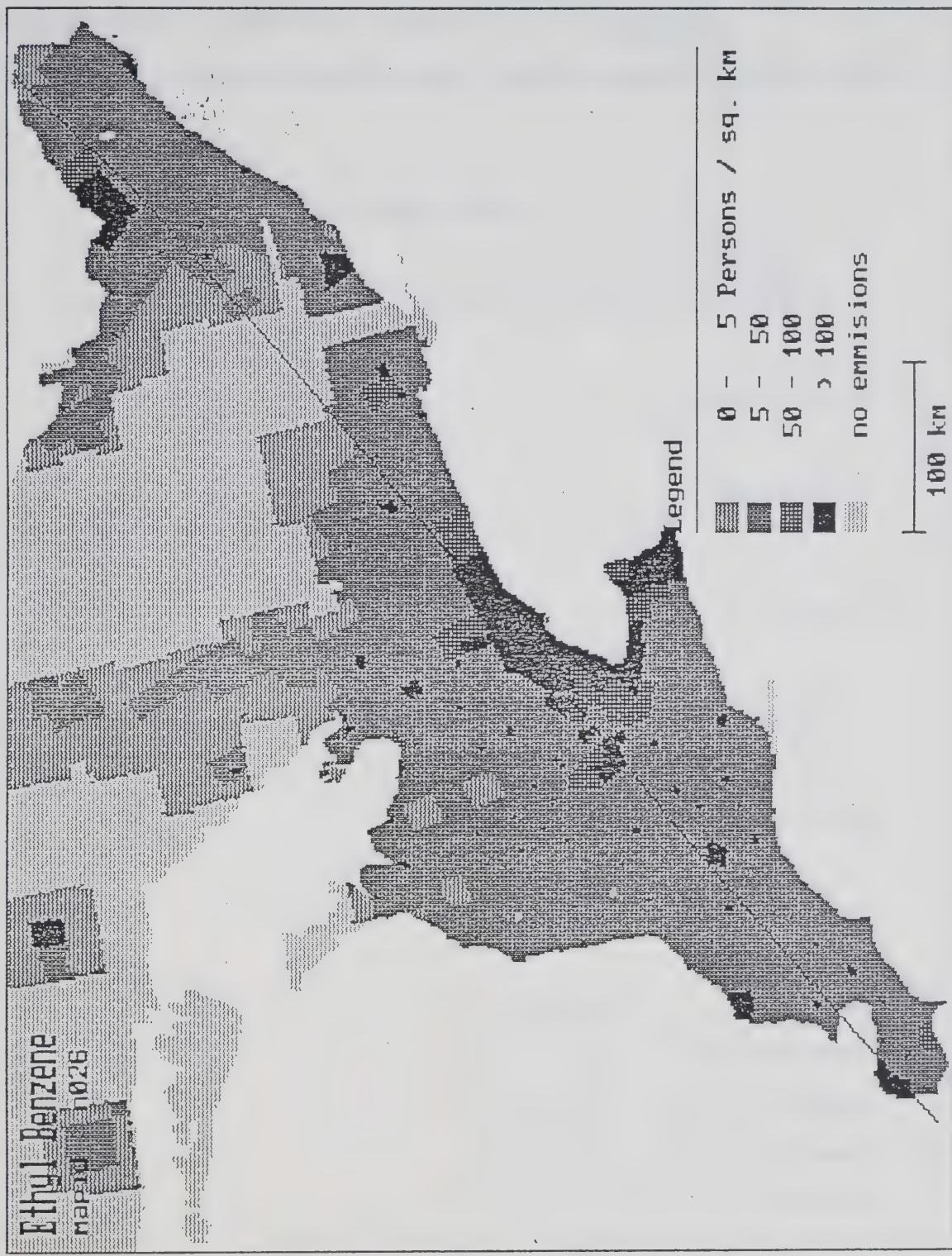
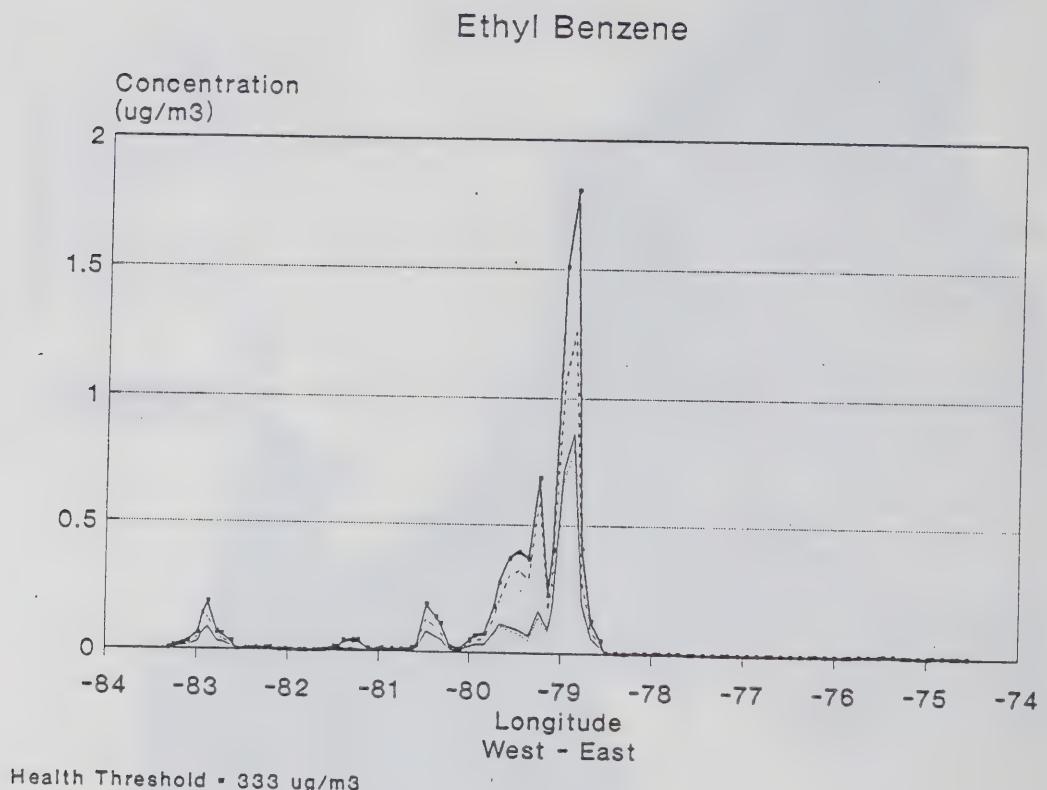


EXHIBIT I.34: PROFILE OF ETHYL BENZENE CONCENTRATION DUE TO
REGULATION 308 SOURCE EMISSIONS ACROSS SOUTHERN
ONTARIO



Legend

- | | |
|-----------------|-------|
| Existing | — |
| Scenarios A & D | — |
| Scenario B | — |
| Scenario C | ----- |
| Scenario E | ===== |

EXHIBIT I.35: AREAS EXPOSED TO ETHYLENE FROM REGULATION 308 SOURCE EMISSIONS

I - 35

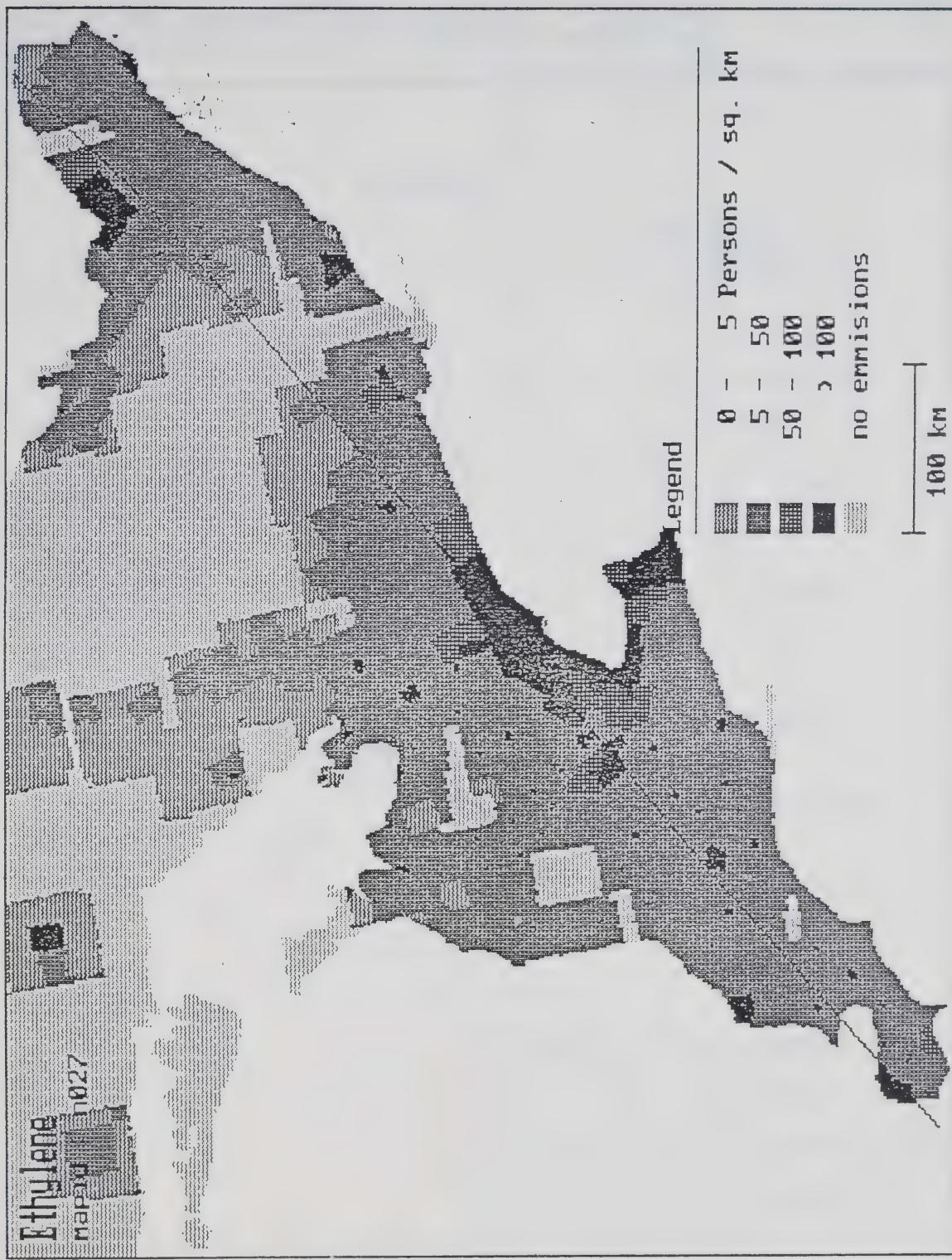
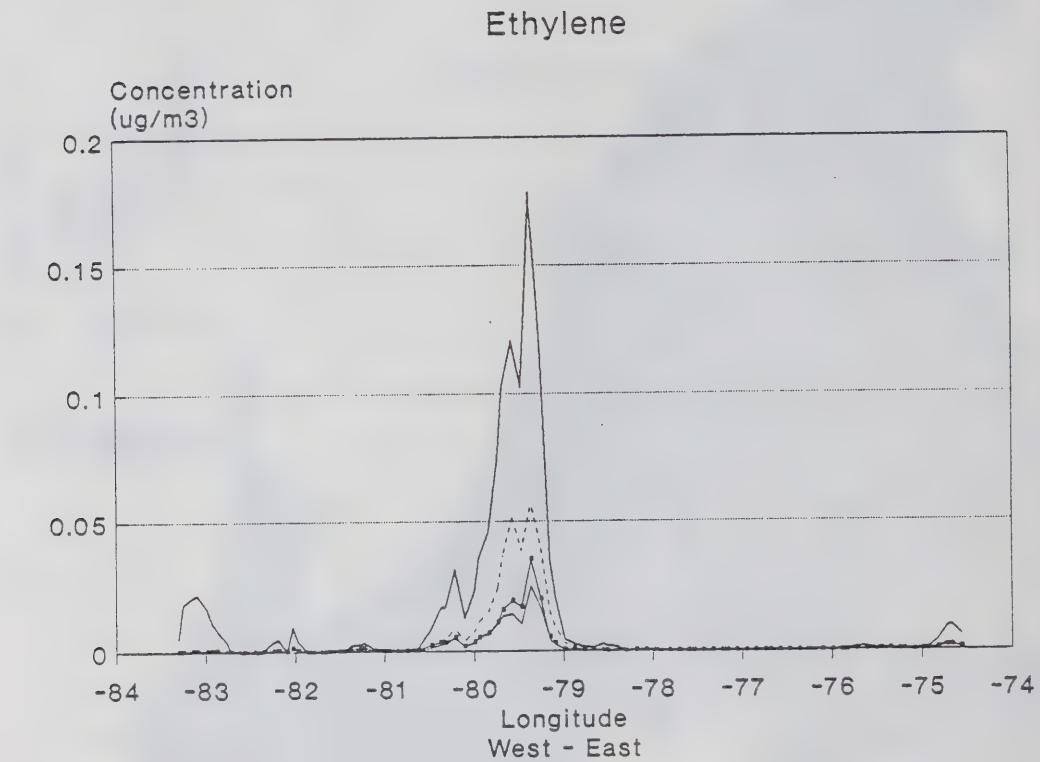


EXHIBIT I.36: PROFILE OF ETHYLENE CONCENTRATION DUE TO REGULATION
308 SOURCE EMISSIONS ACROSS SOUTHERN ONTARIO



Legend

- | | |
|-----------------|-------|
| Existing | — |
| Scenarios A & D | — |
| Scenario B | — |
| Scenario C | ----- |
| Scenario E | ..... |

EXHIBIT I.37: AREAS EXPOSED TO ETHYLENE DIBROMIDE FROM REGULATION 308 SOURCE EMISSIONS

I - 37

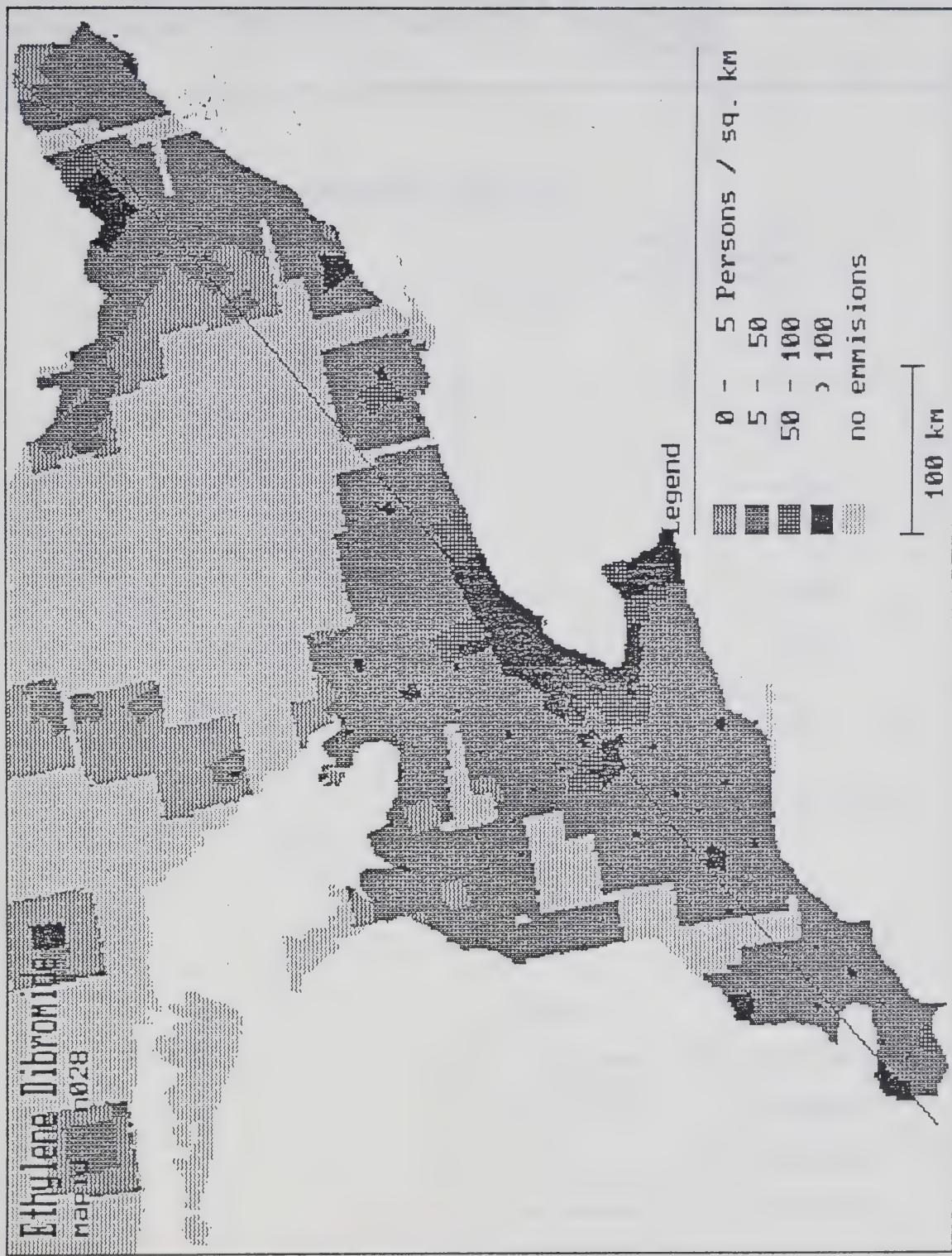
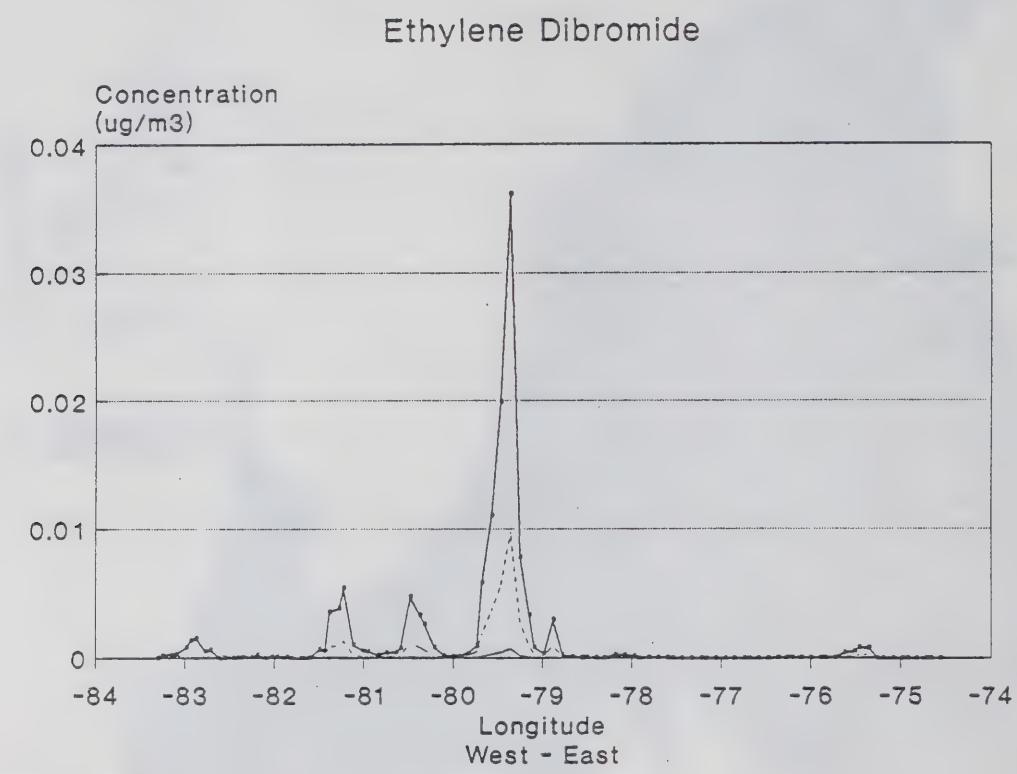


EXHIBIT I.38: PROFILE OF ETHYLENE DIBROMIDE CONCENTRATION DUE TO REGULATION 308 SOURCE EMISSIONS ACROSS SOUTHERN ONTARIO



Legend

- Existing _____
- Scenarios A & D _____
- Scenario B _____
- Scenario C _____
- Scenario E _____

EXHIBIT I.39: AREAS EXPOSED TO ETHYLENE DICHLORIDE FROM REGULATION 308 SOURCE EMISSIONS

I - 39

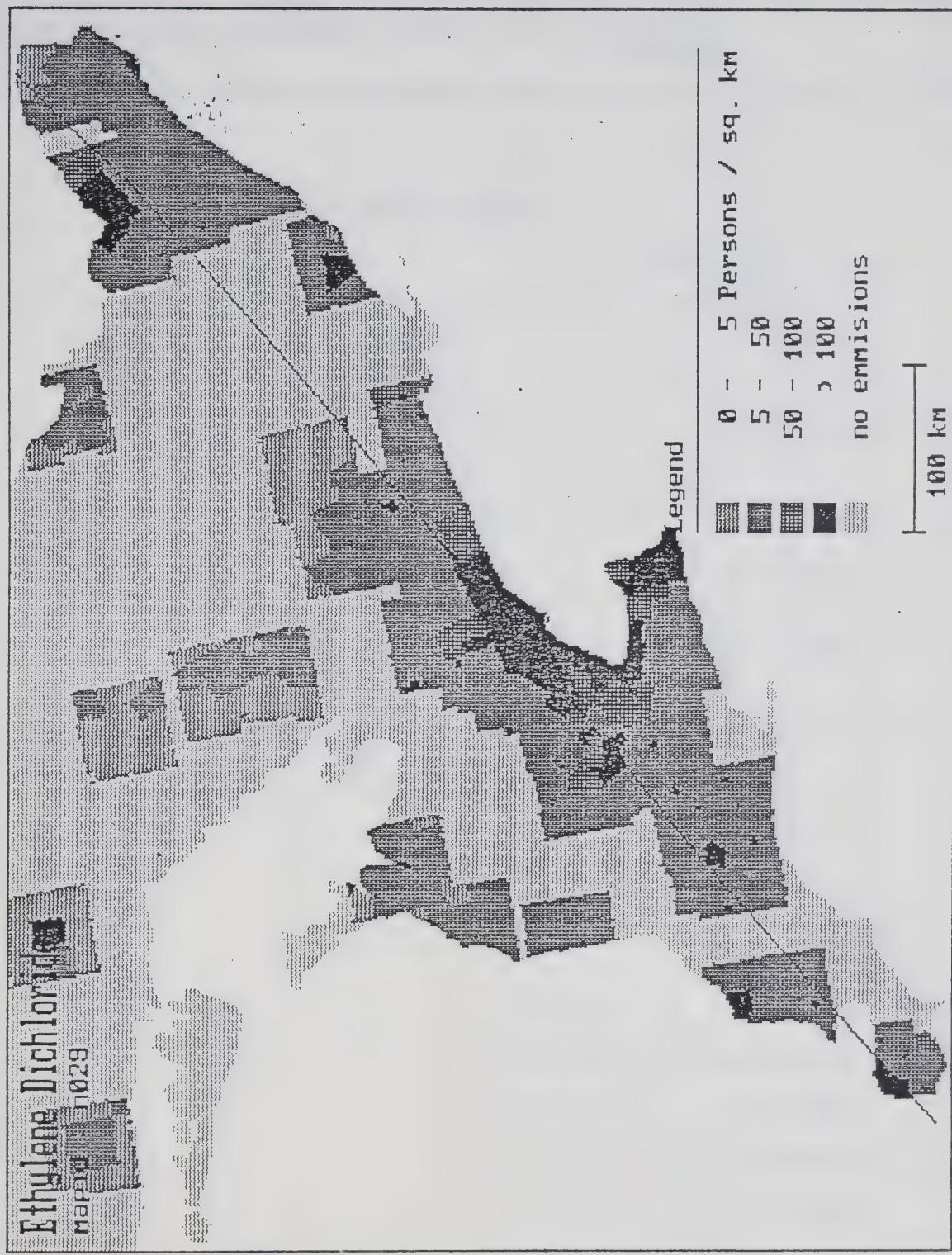
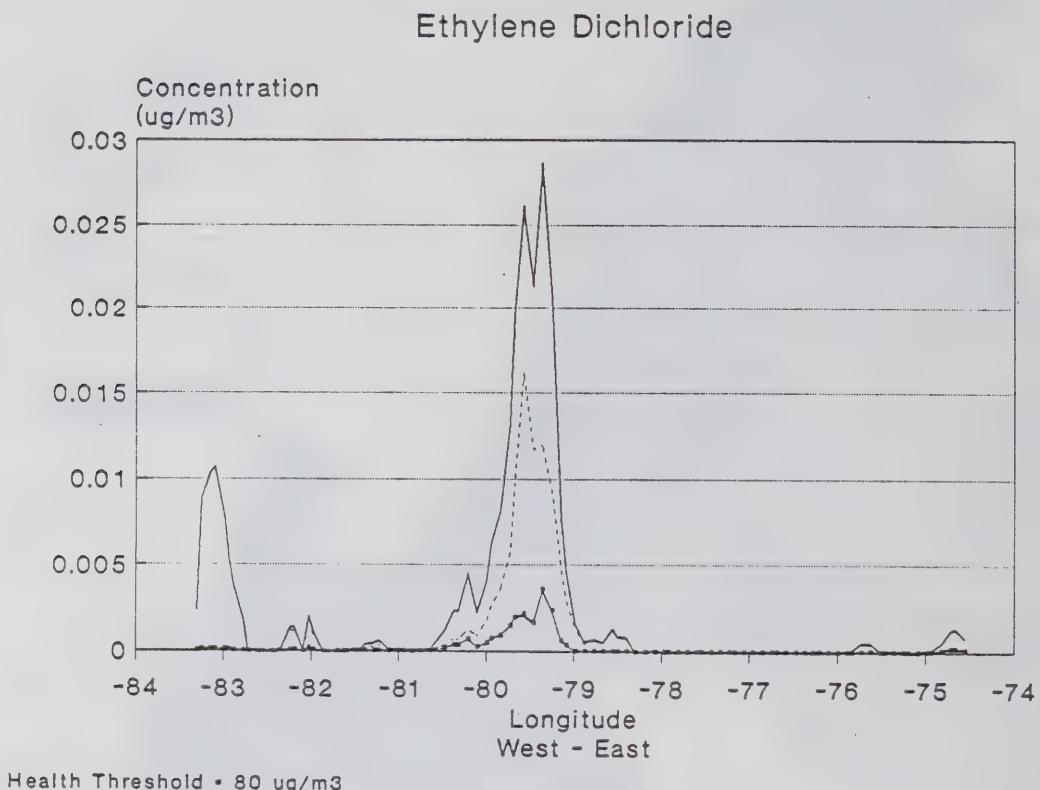


EXHIBIT I.40: PROFILE OF ETHYLENE DICHLORIDE CONCENTRATION DUE TO
REGULATION 308 SOURCE EMISSIONS ACROSS SOUTHERN
ONTARIO



Legend

- | | |
|-----------------|-------|
| Existing | — |
| Scenarios A & D | — |
| Scenario B | — |
| Scenario C | ..... |
| Scenario E | .... |

EXHIBIT I.41: AREAS EXPOSED TO BUTYL CELLOSOLVE FROM REGULATION 308 SOURCE EMISSIONS

I - 41

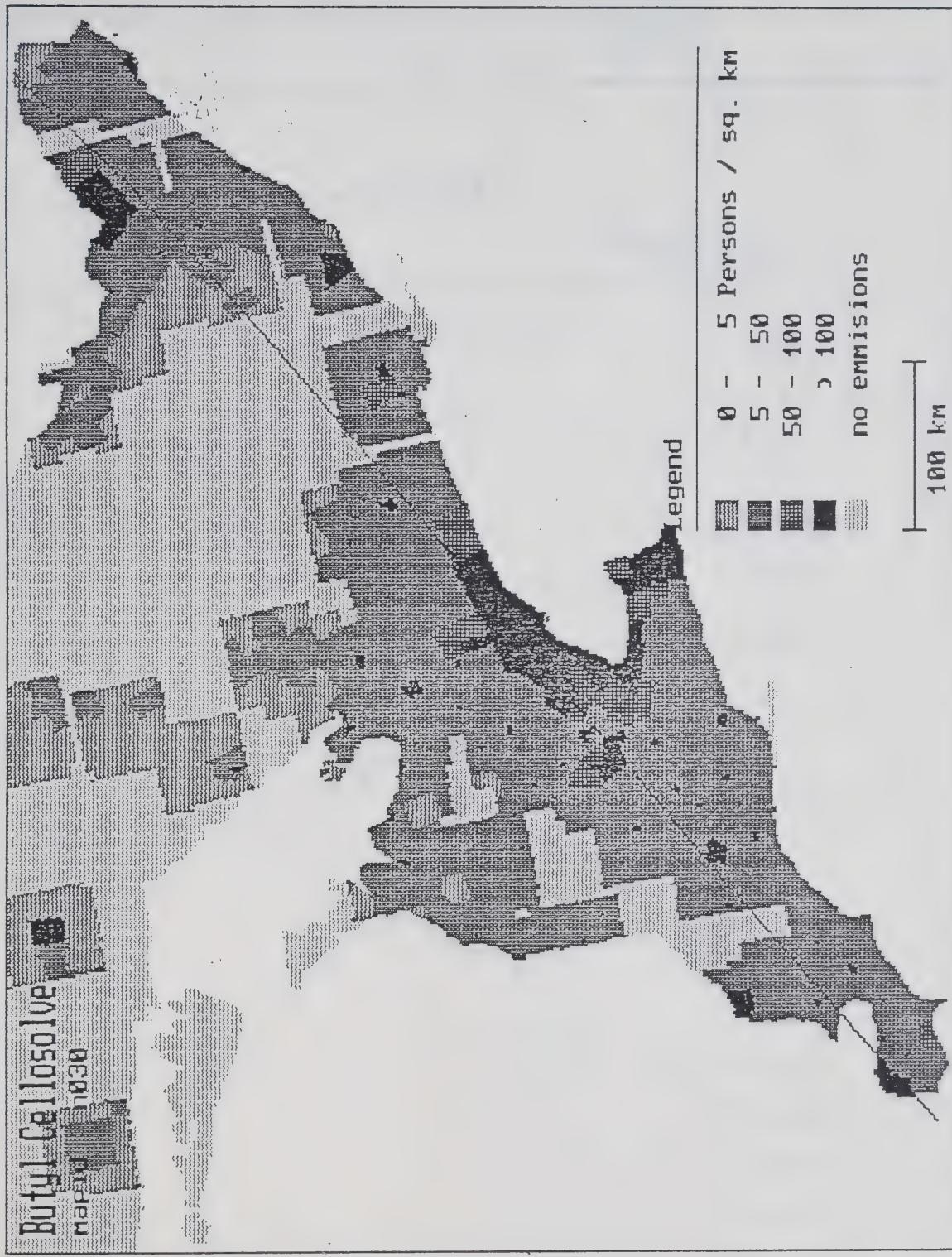
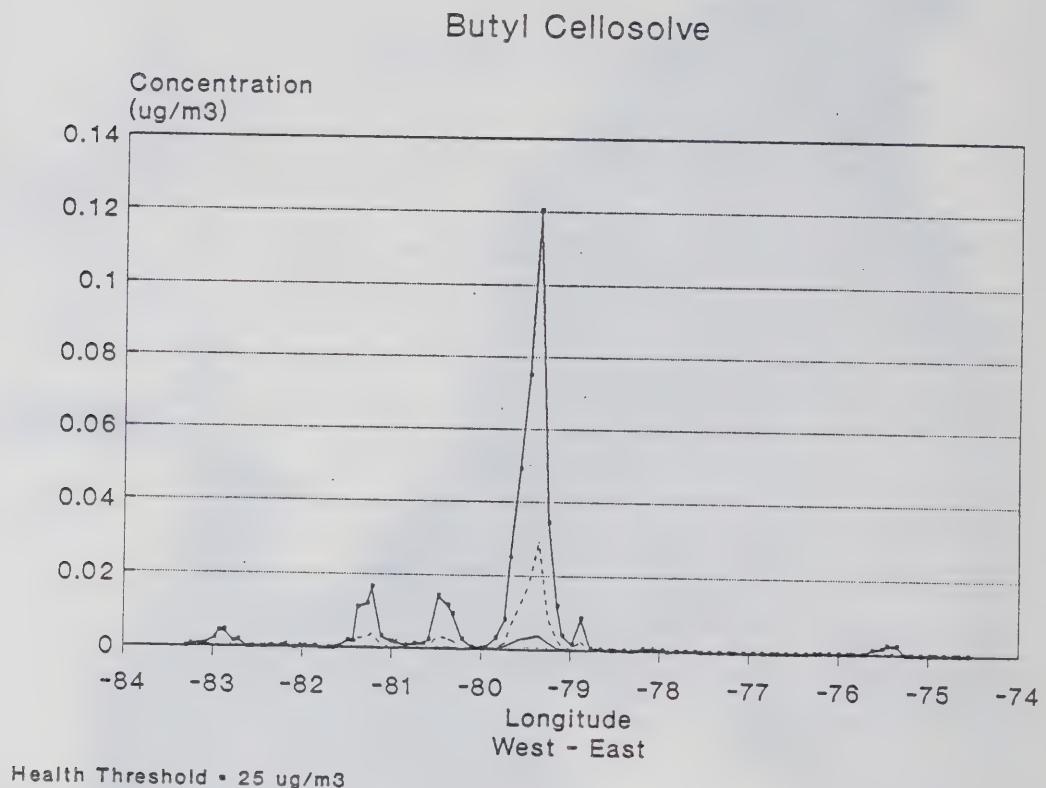


EXHIBIT I.42: PROFILE OF BUTYL CELLOSOLVE CONCENTRATION DUE TO REGULATION 308 SOURCE EMISSIONS ACROSS SOUTHERN ONTARIO



Legend

- | | |
|-----------------|-------|
| Existing | _____ |
| Scenarios A & D | _____ |
| Scenario B | _____ |
| Scenario C | ..... |
| Scenario E | ..... |

EXHIBIT I.43: AREAS EXPOSED TO CELLOSOLVE FROM REGULATION 308 SOURCE EMISSIONS

I - 43

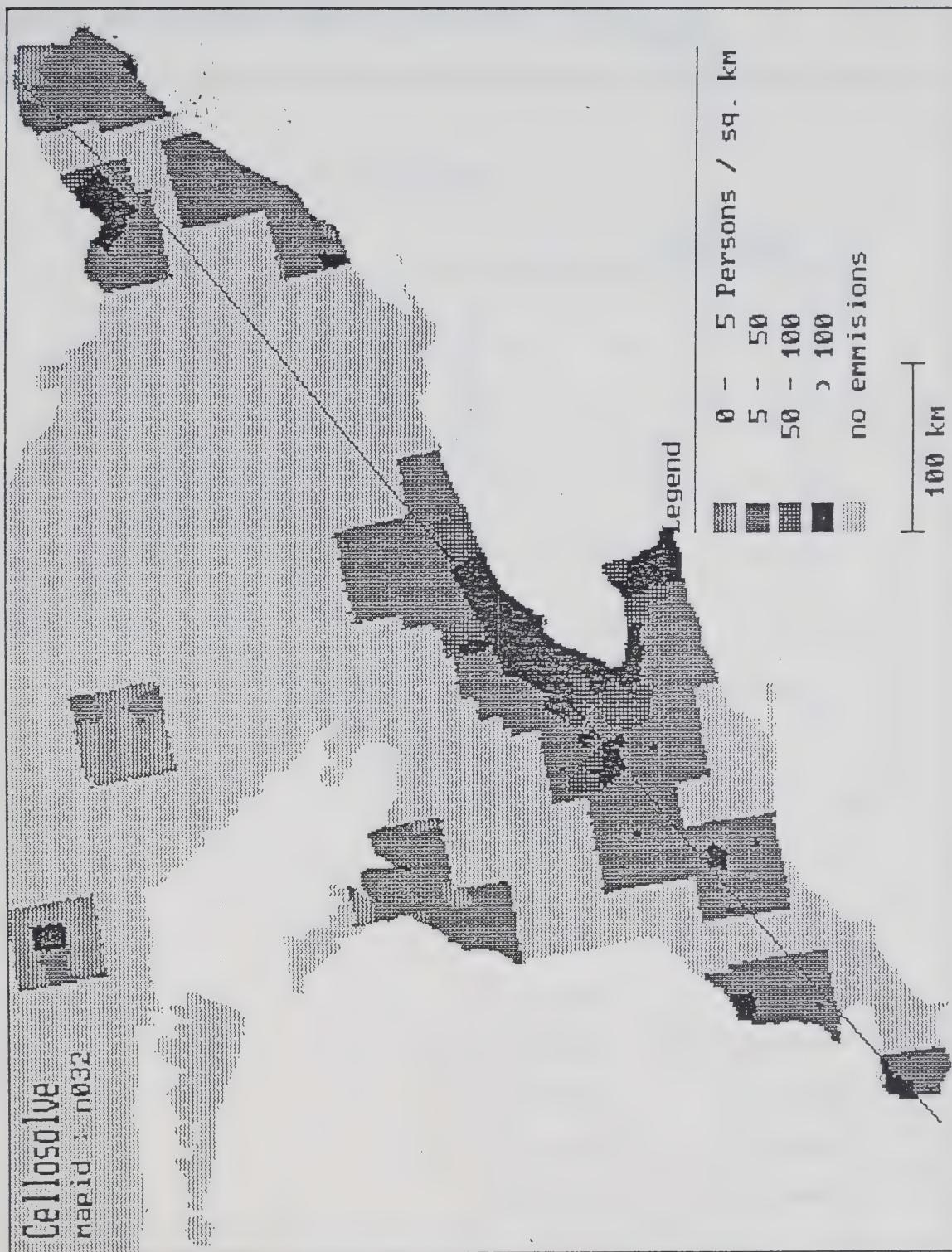
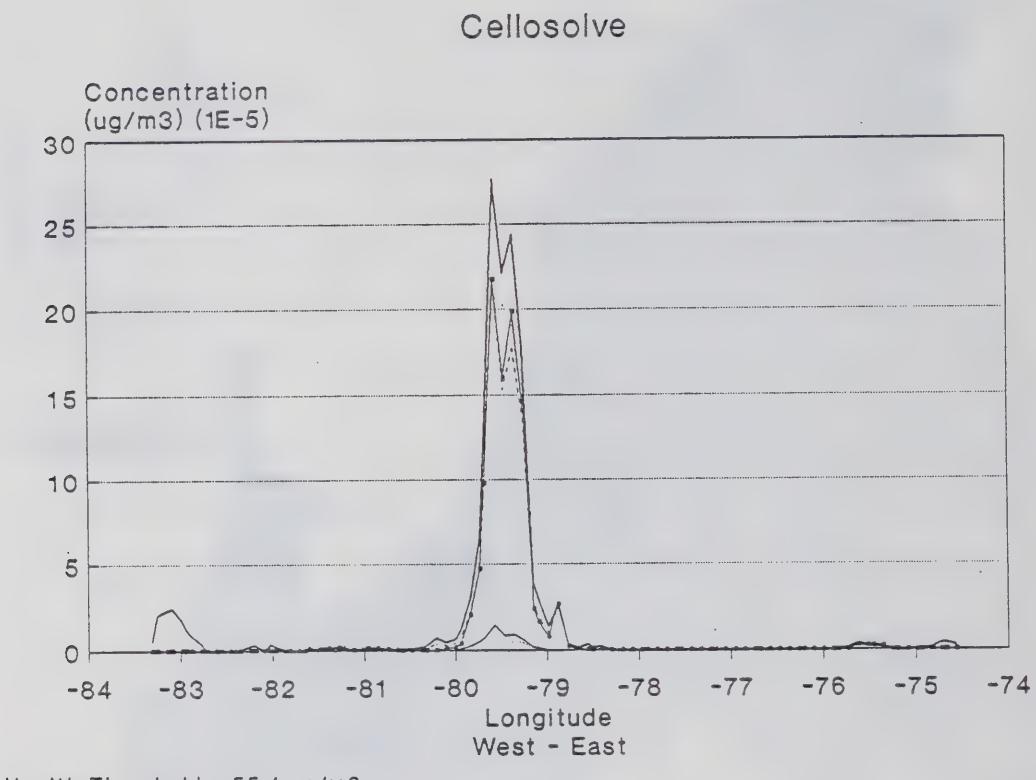


EXHIBIT I.44: PROFILE OF CELLOSOLVE CONCENTRATION DUE TO
REGULATION 308 SOURCE EMISSIONS ACROSS SOUTHERN
ONTARIO



Legend

- | | |
|-----------------|-------|
| Existing | _____ |
| Scenarios A & D | _____ |
| Scenario B | _____ |
| Scenario C | ..... |
| Scenario E | ..... |

EXHIBIT I-45: AREAS EXPOSED TO CELLOSOLVE ACETATE FROM REGULATION 308 SOURCE EMISSIONS

I - 45

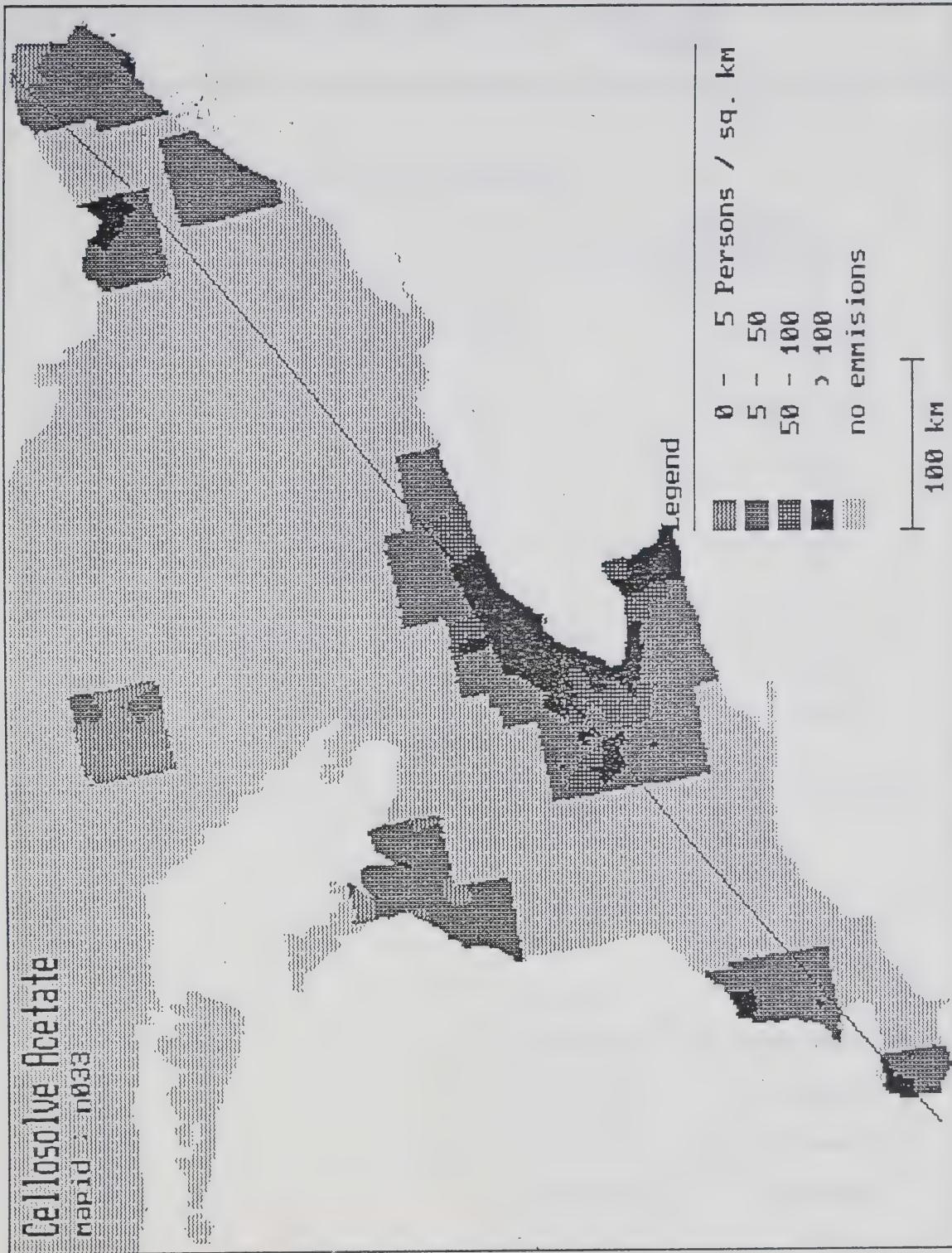
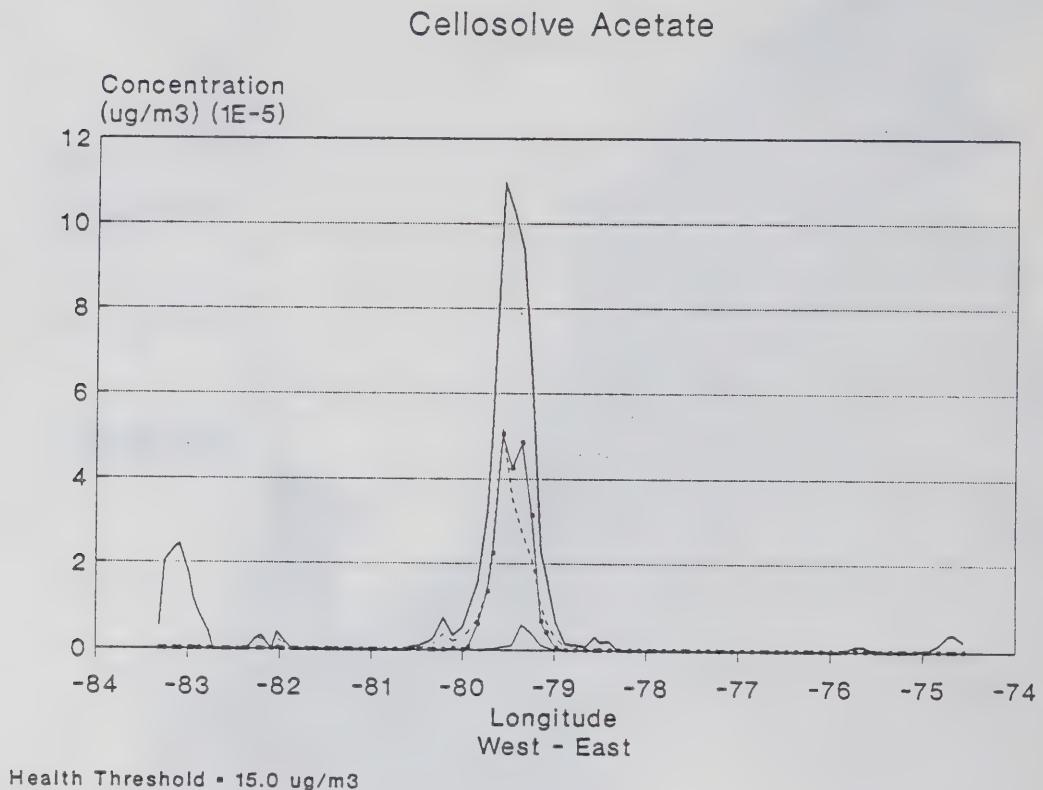


EXHIBIT I.46: PROFILE OF CELLOSOLVE ACETATE CONCENTRATION DUE TO
REGULATION 308 SOURCE EMISSIONS ACROSS SOUTHERN
ONTARIO



Legend

- Existing _____
- Scenarios A & D _____
- Scenario B _____
- Scenario C -----
- Scenario E *****

EXHIBIT I.47: AREAS EXPOSED TO ETHYLENE OXIDE FROM REGULATION 308 SOURCE EMISSIONS

I - 47

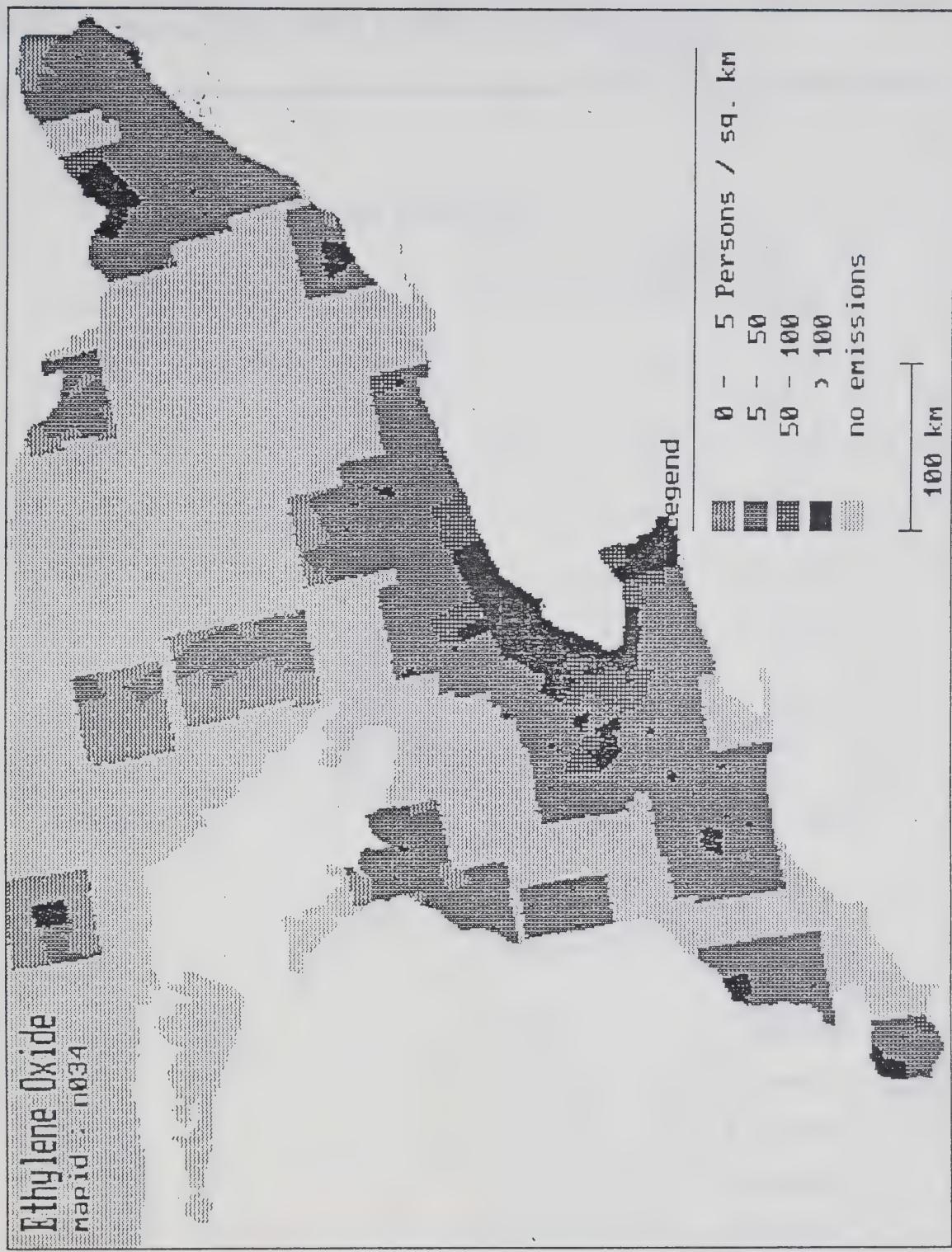
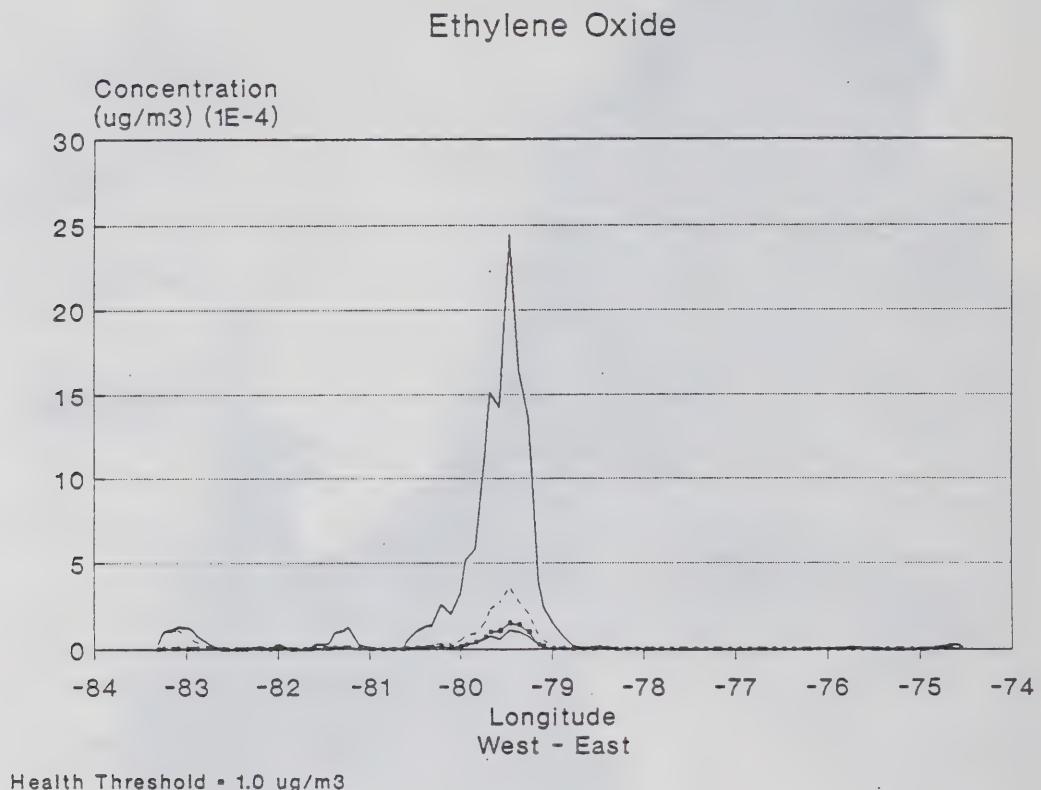


EXHIBIT I.48: PROFILE OF ETHYLENE OXIDE CONCENTRATION DUE TO
REGULATION 308 SOURCE EMISSIONS ACROSS SOUTHERN
ONTARIO



Legend

- | | |
|-----------------|-------|
| Existing | — |
| Scenarios A & D | — |
| Scenario B | — |
| Scenario C | ----- |
| Scenario E | ***** |

EXHIBIT I.49: AREAS EXPOSED TO FLUORIDES FROM REGULATION 308 SOURCE EMISSIONS

I - 49

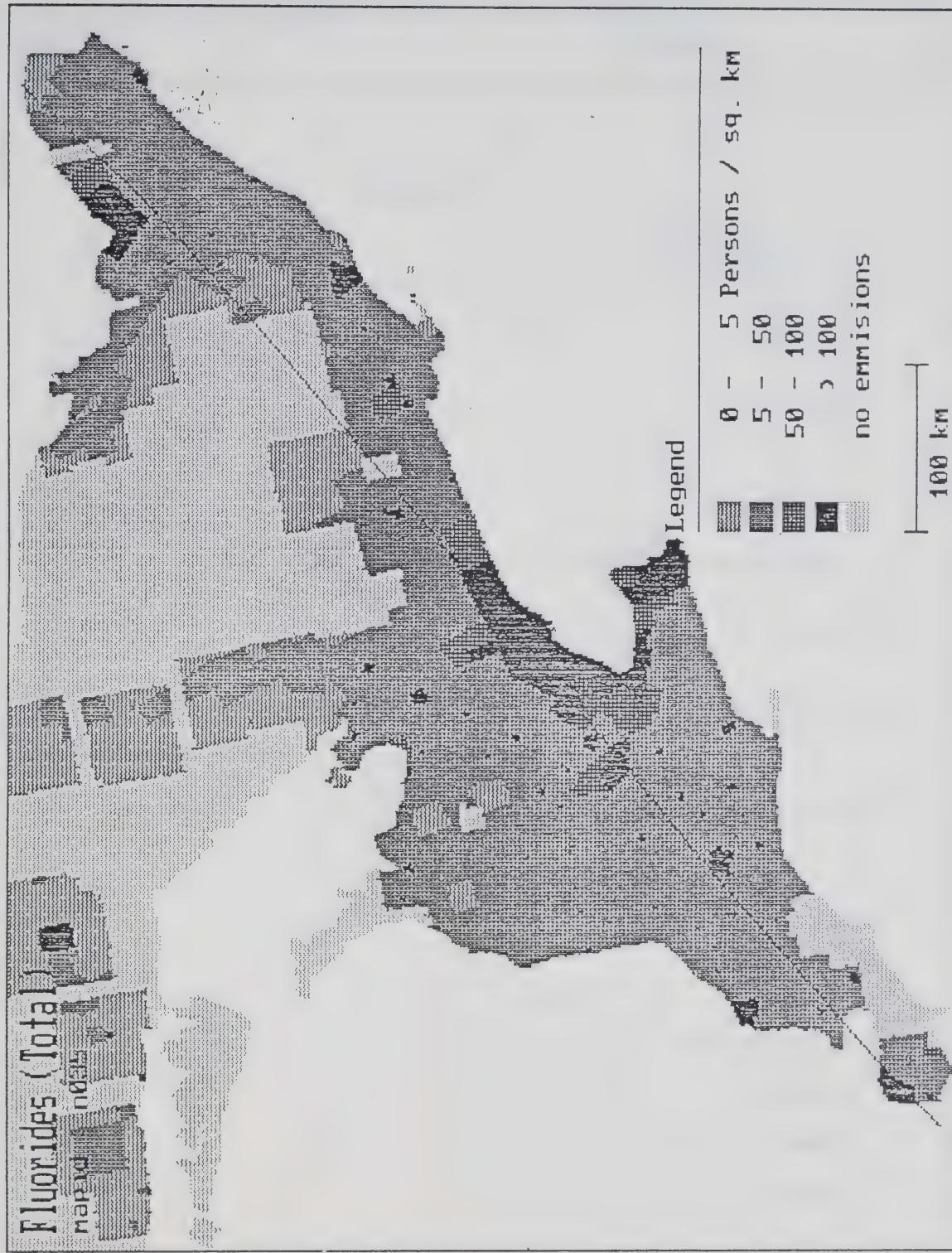
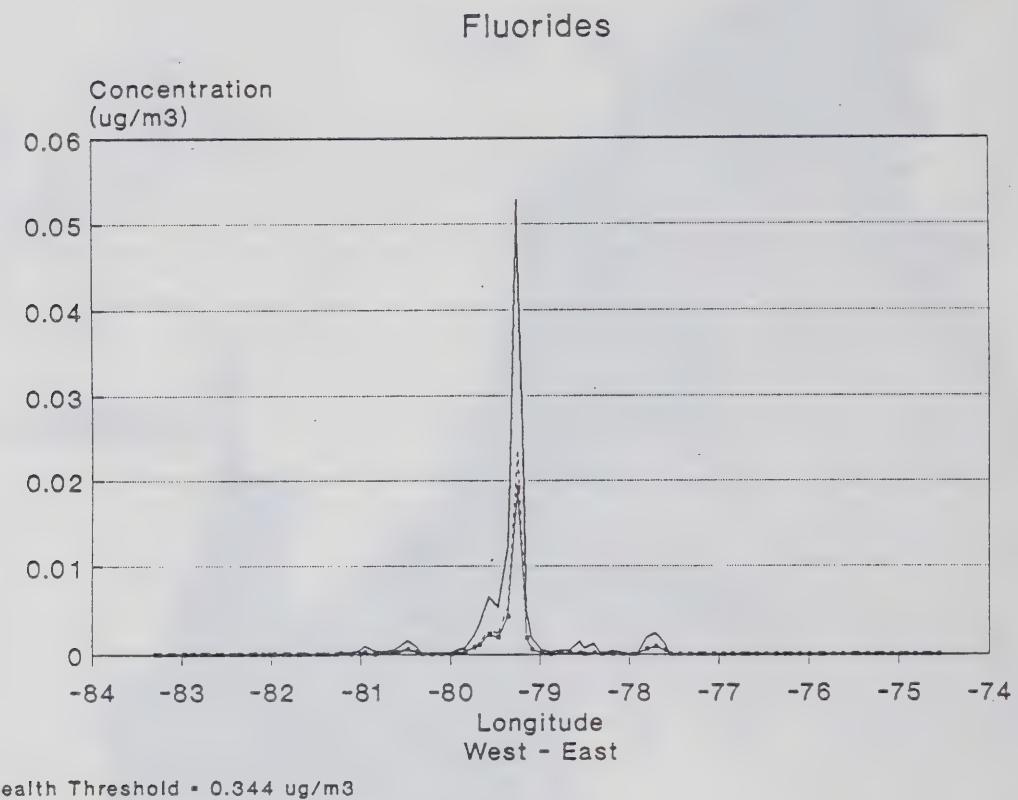


EXHIBIT I.50: PROFILE OF FLUORIDES CONCENTRATION DUE TO
REGULATION 308 SOURCE EMISSIONS ACROSS SOUTHERN
ONTARIO



Legend

- | | |
|-----------------|-------|
| Existing | — |
| Scenarios A & D | — |
| Scenario B | — |
| Scenario C | ----- |
| Scenario E | ===== |

EXHIBIT I.51: AREAS EXPOSED TO FORMALDEHYDE FROM REGULATION 308 SOURCE EMISSIONS

I - 51

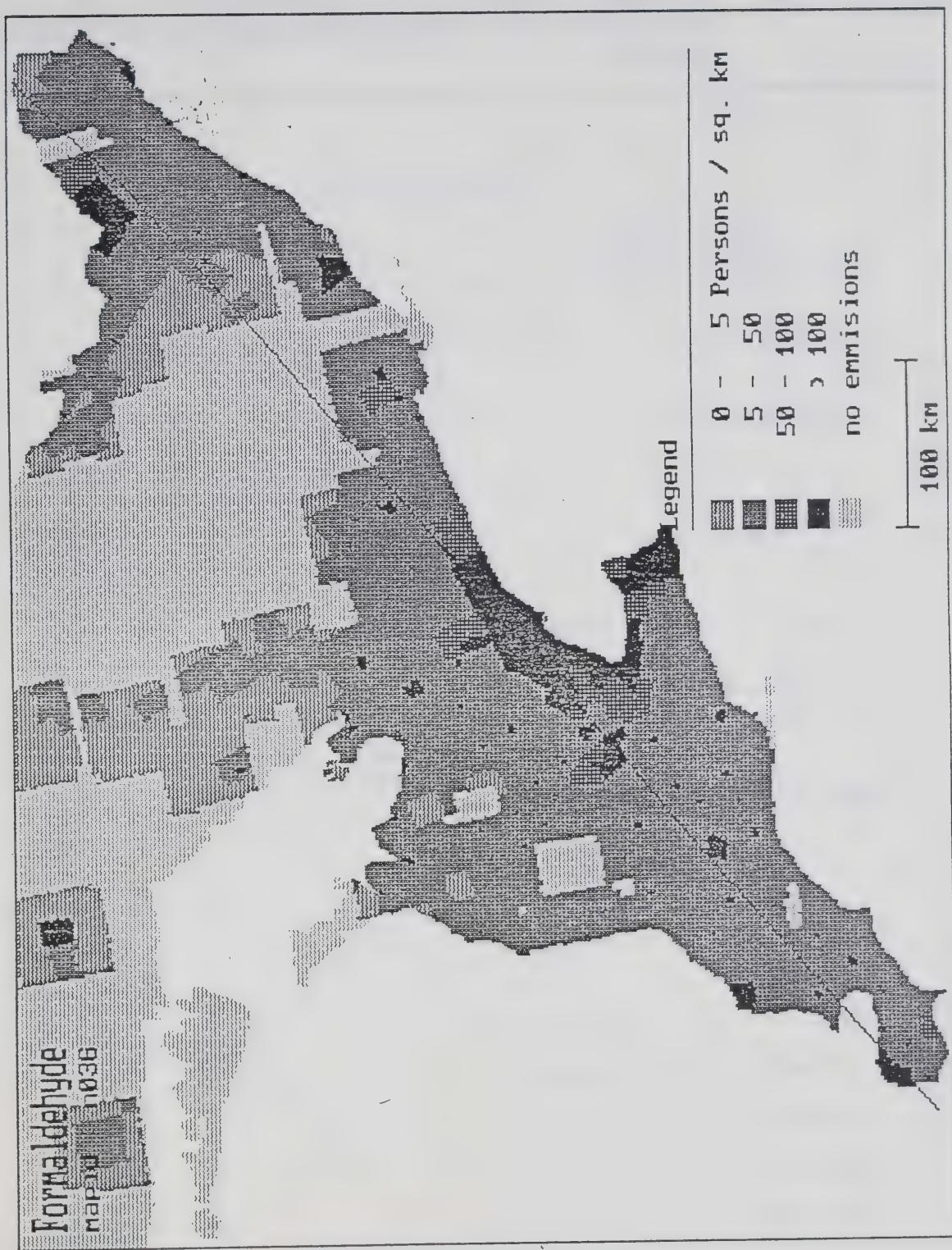
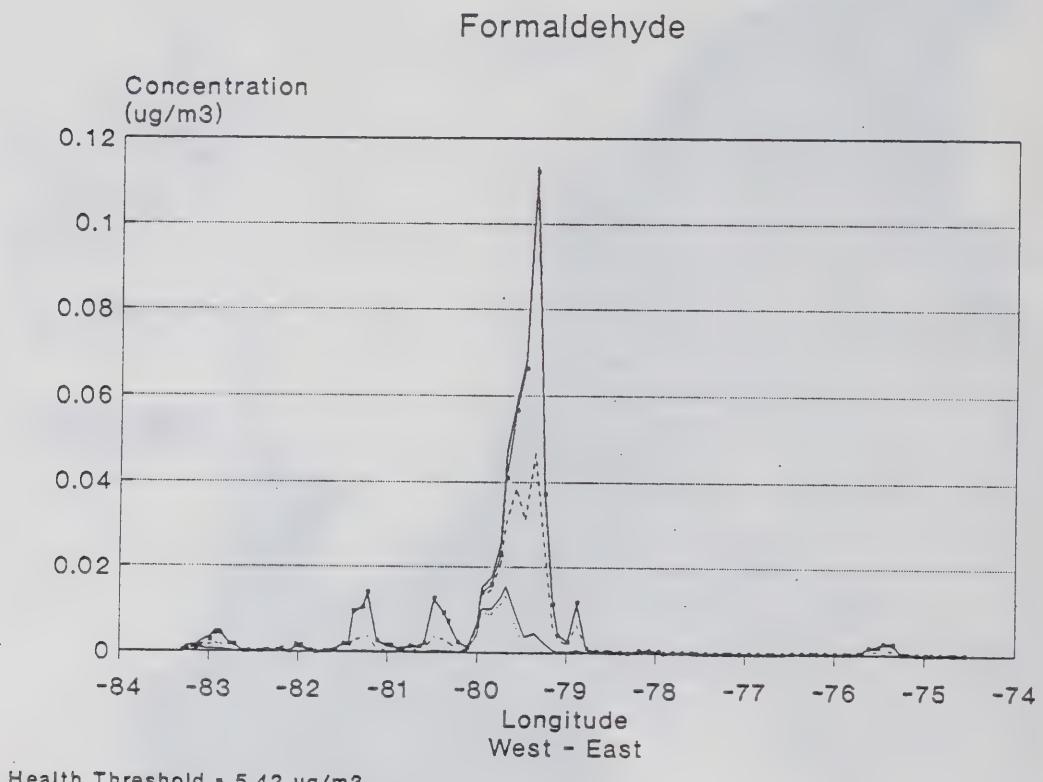


EXHIBIT I.52: PROFILE OF FORMALDEHYDE CONCENTRATION DUE TO
REGULATION 308 SOURCE EMISSIONS ACROSS SOUTHERN
ONTARIO



Legend

- | | |
|-----------------|-------|
| Existing | _____ |
| Scenarios A & D | _____ |
| Scenario B | _____ |
| Scenario C | ----- |
| Scenario E | ..... |

EXHIBIT I.53: AREAS EXPOSED TO HYDROGEN CHLORIDE FROM REGULATION 308 SOURCE EMISSIONS

I - 53

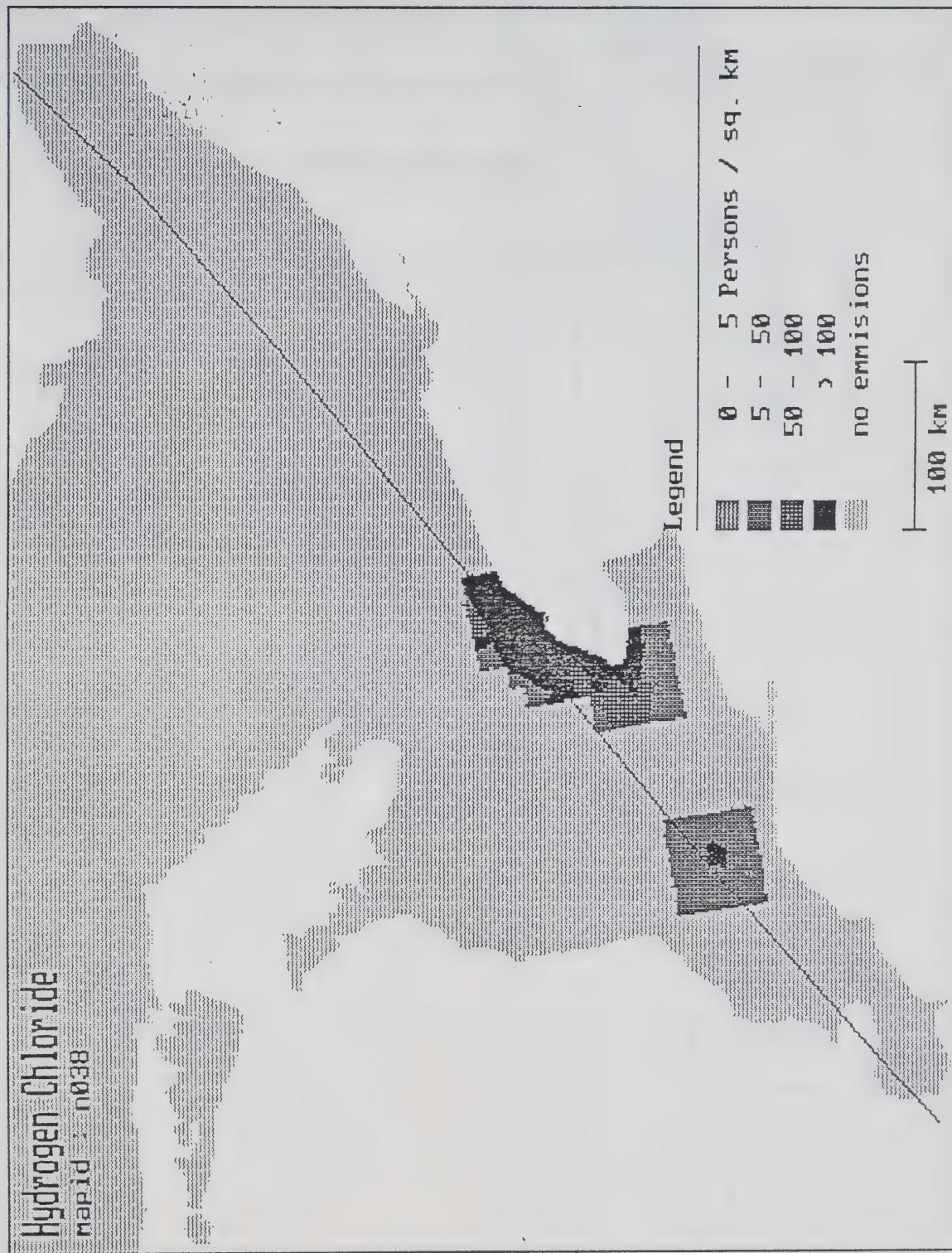
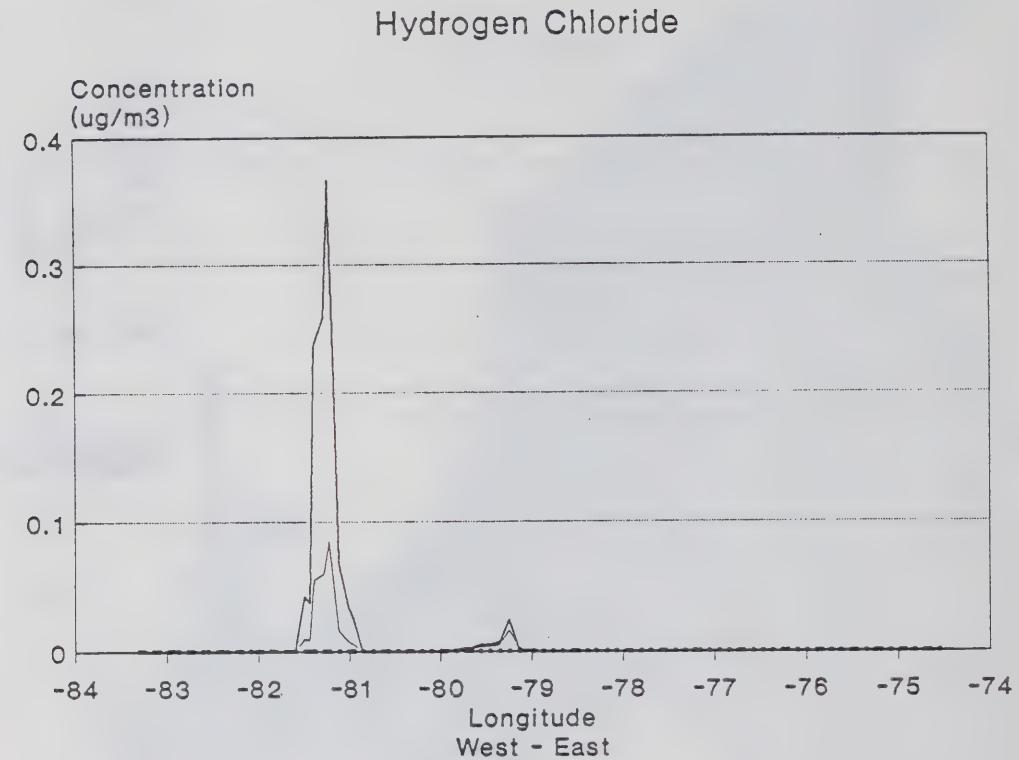


EXHIBIT I.54: PROFILE OF HYDROGEN CHLORIDE CONCENTRATION DUE TO
REGULATION 308 SOURCE EMISSIONS ACROSS SOUTHERN
ONTARIO



Legend

- | | |
|-----------------|-------|
| Existing | _____ |
| Scenarios A & D | _____ |
| Scenario B | _____ |
| Scenario C | ----- |
| Scenario E | ***** |

EXHIBIT I.55: AREAS EXPOSED TO LEAD FROM REGULATION 308 SOURCE EMISSIONS

H - 55

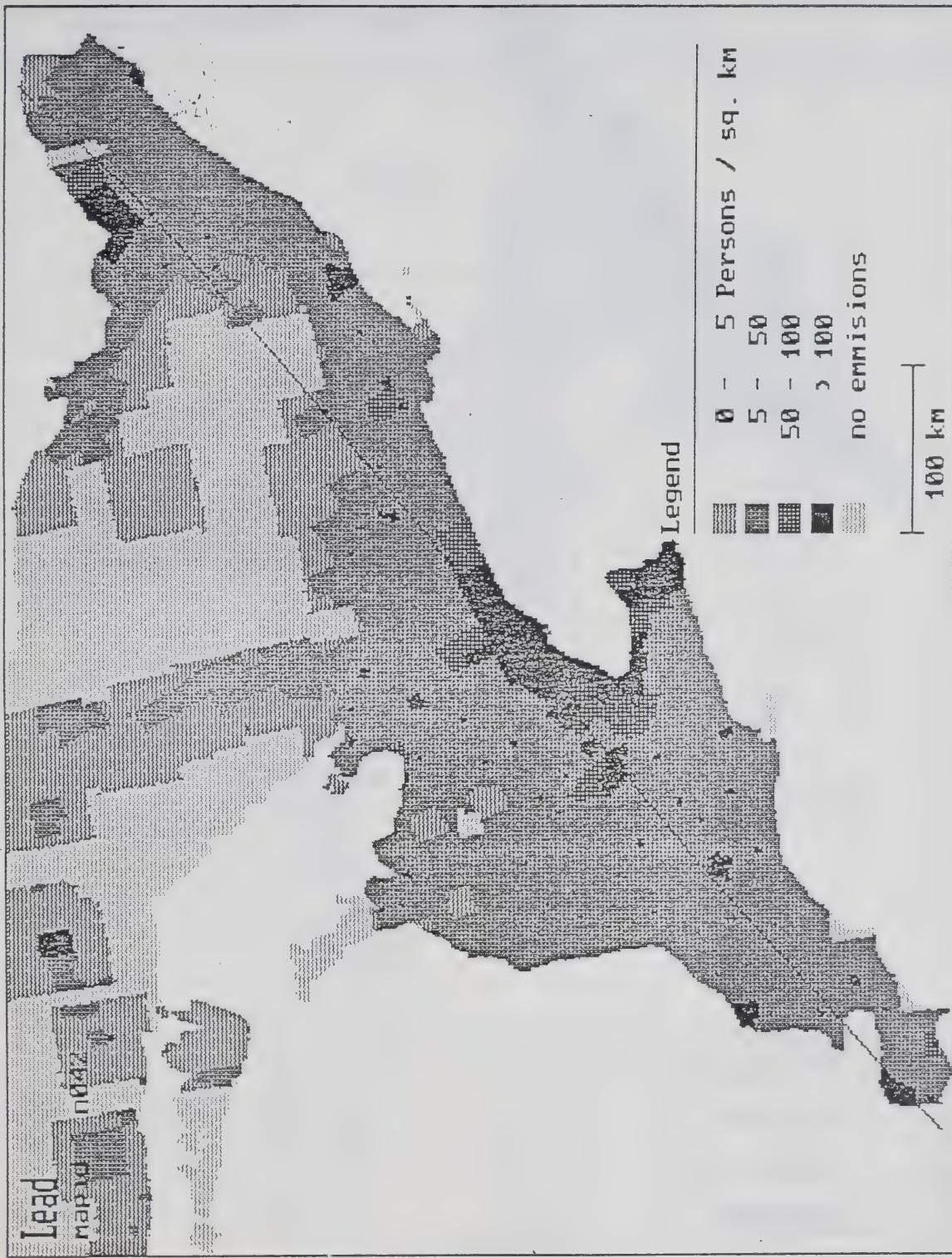
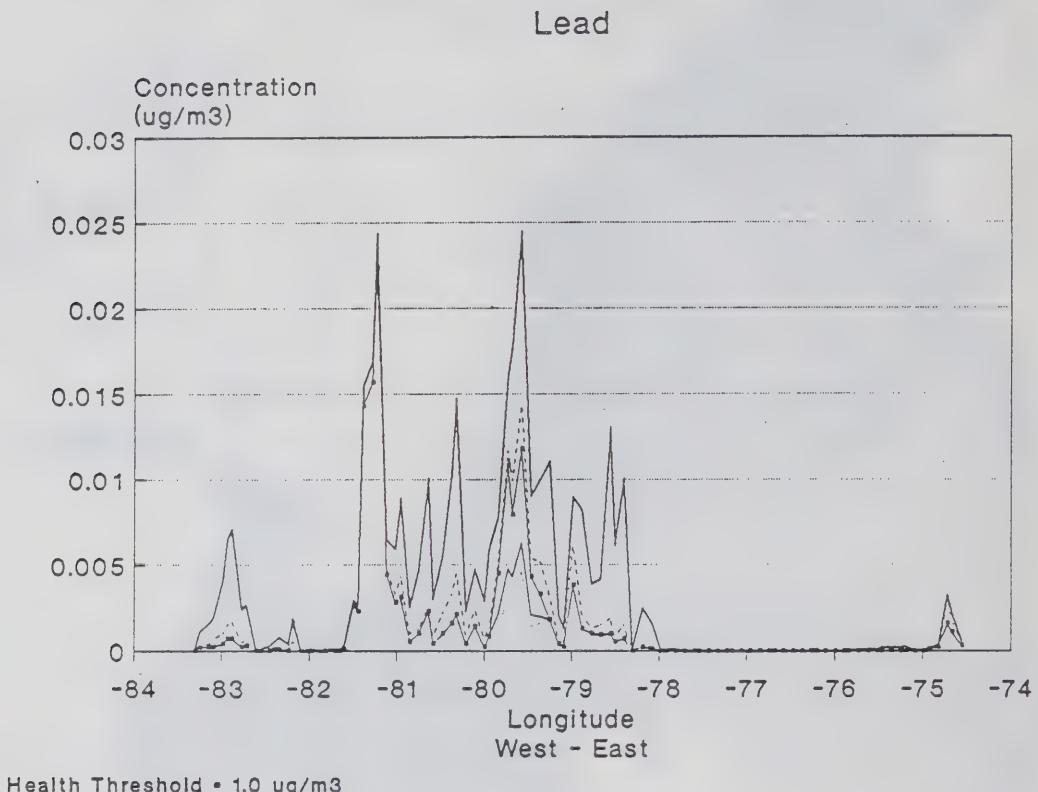


EXHIBIT I.56: PROFILE OF LEAD CONCENTRATION DUE TO REGULATION 308
SOURCE EMISSIONS ACROSS SOUTHERN ONTARIO



Legend

- | | |
|-----------------|-------|
| Existing | _____ |
| Scenarios A & D | _____ |
| Scenario B | _____ |
| Scenario C | ..... |
| Scenario E | ***** |

EXHIBIT I.57: AREAS EXPOSED TO MANGANESE COMPOUNDS FROM REGULATION 308 SOURCE EMISSIONS

I - 57

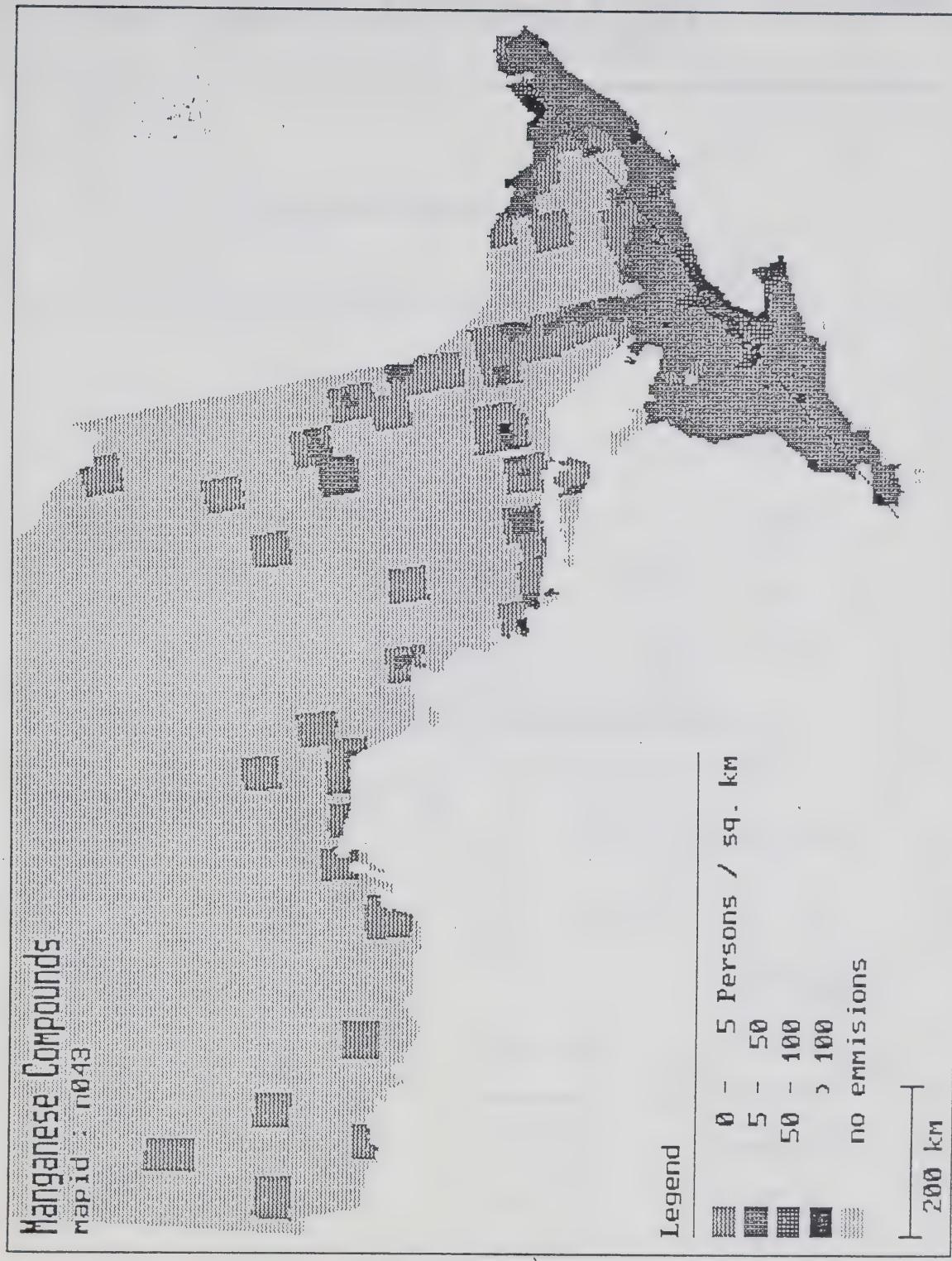
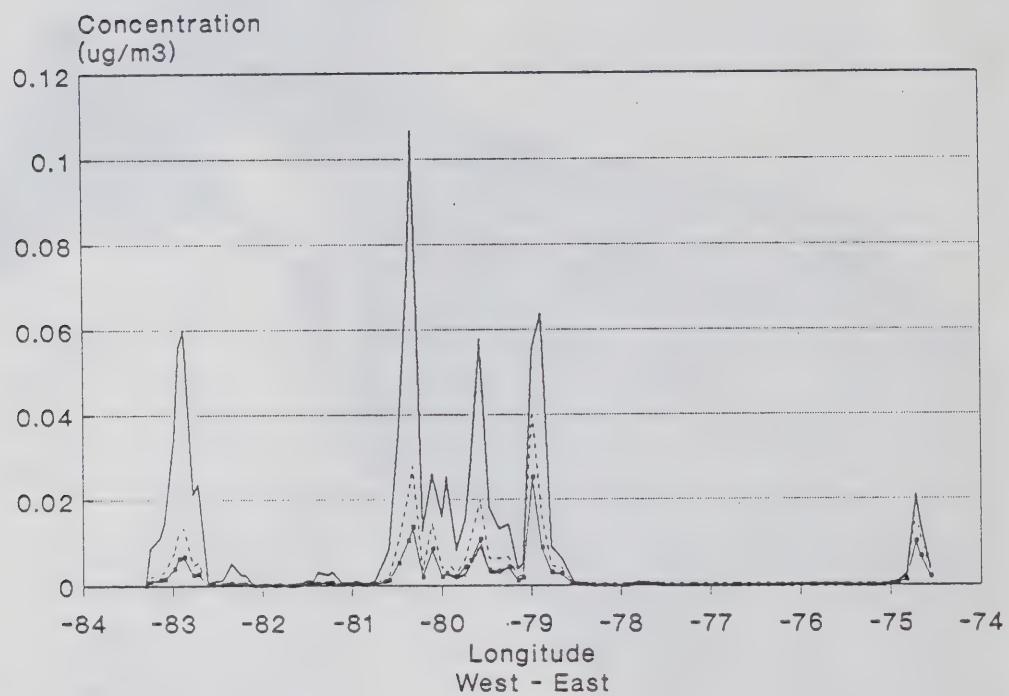


EXHIBIT I.58: PROFILE OF MANGANESE COMPOUNDS CONCENTRATION DUE TO REGULATION 308 SOURCE EMISSIONS ACROSS SOUTHERN ONTARIO

Manganese Compounds



Legend

- | | |
|-----------------|-------|
| Existing | — |
| Scenarios A & D | — |
| Scenario B | — |
| Scenario C | ..... |
| Scenario E | .... |
-

EXHIBIT I.59: AREAS EXPOSED TO MERCURY FROM REGULATION 308 SOURCE EMISSIONS

I - 59

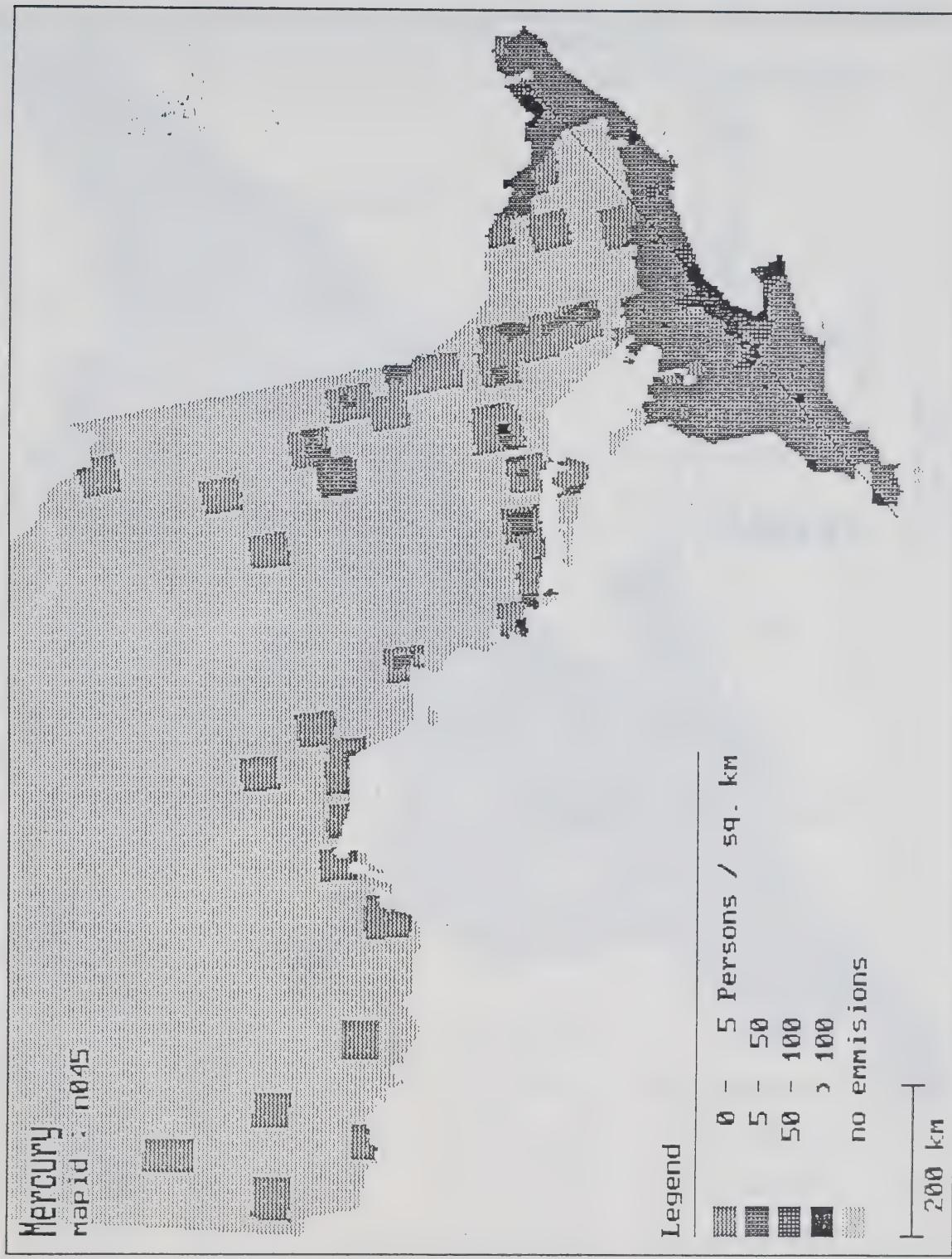
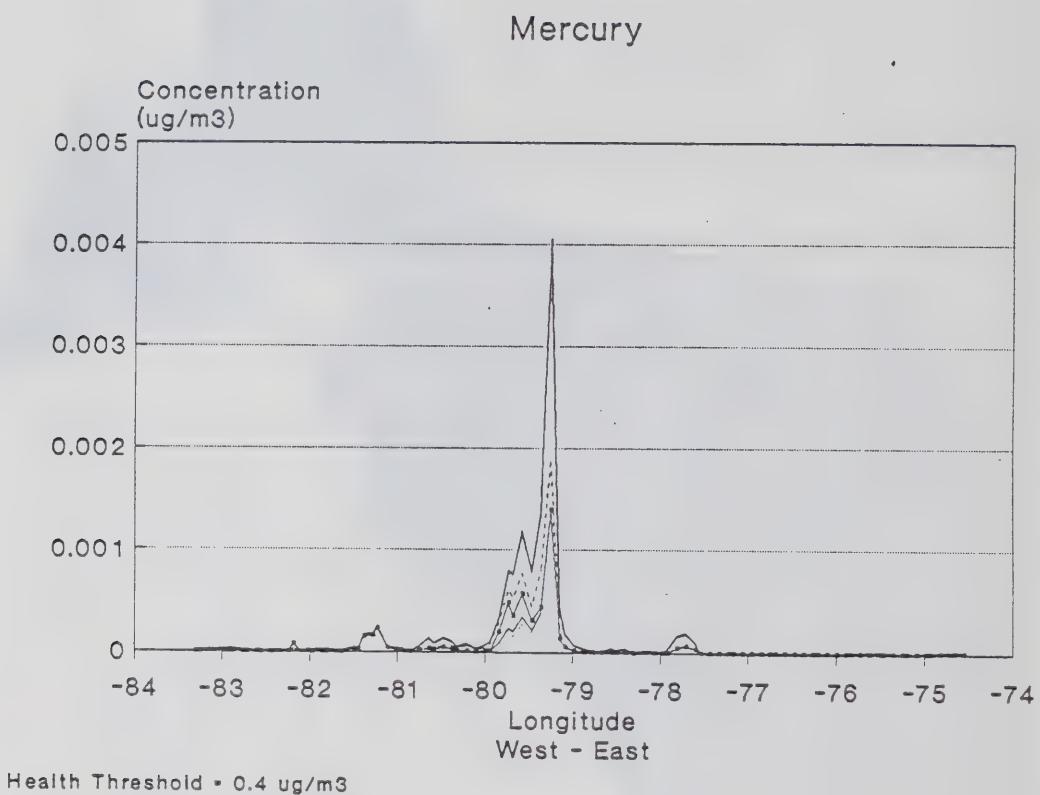


EXHIBIT I.60: PROFILE OF MERCURY CONCENTRATION DUE TO REGULATION
308 SOURCE EMISSIONS ACROSS SOUTHERN ONTARIO



Legend

- Existing _____
- Scenarios A & D _____
- Scenario B _____
- Scenario C -----
- Scenario E *****

EXHIBIT I-61: AREAS EXPOSED TO METHYL ISOBUTYL KETONE FROM REGULATION 308 SOURCE EMISSIONS

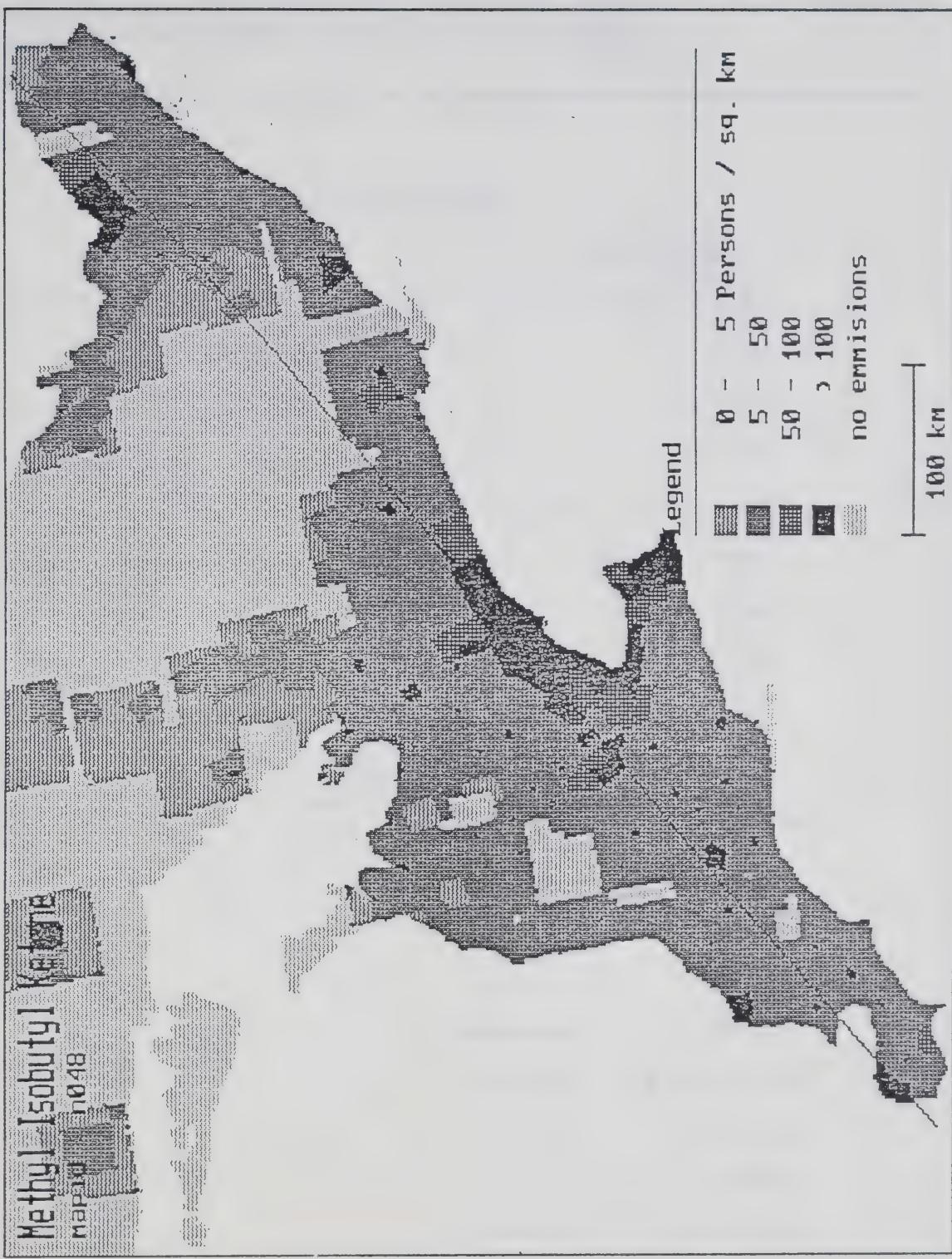
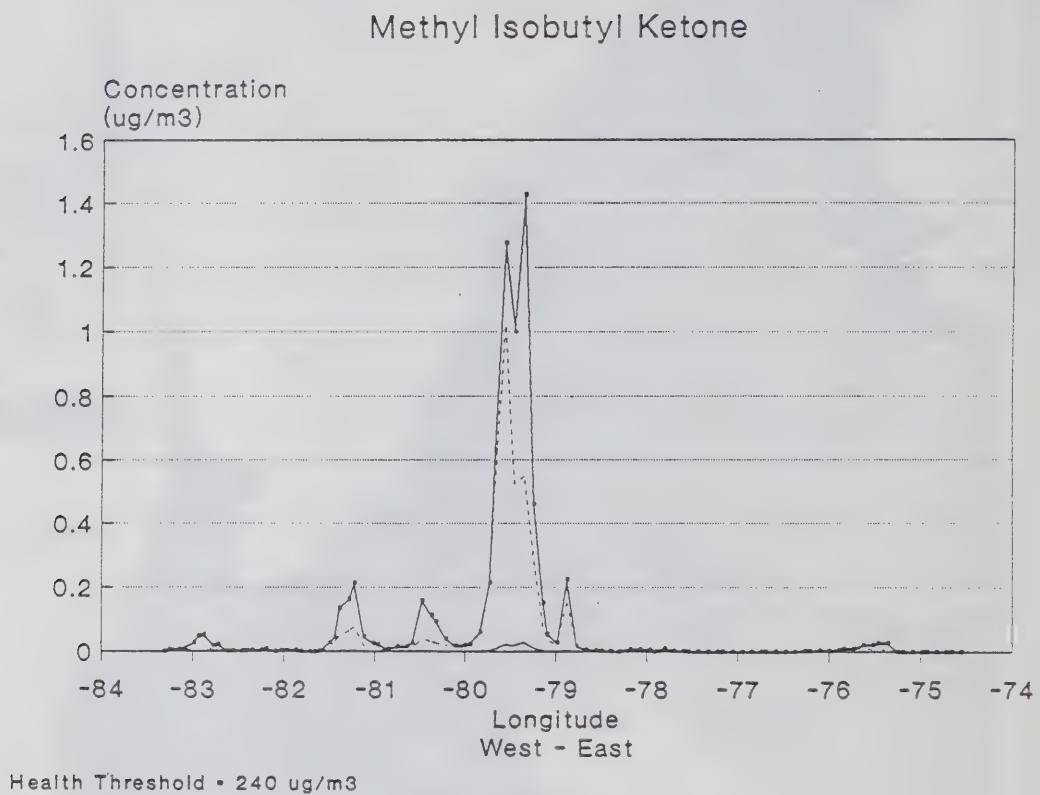


EXHIBIT I.62: PROFILE OF METHYL ISOBUTYL KETONE CONCENTRATION DUE TO REGULATION 308 SOURCE EMISSIONS ACROSS SOUTHERN ONTARIO



Legend

- | | |
|-----------------|-------|
| Existing | — |
| Scenarios A & D | — |
| Scenario B | — |
| Scenario C | ----- |
| Scenario E | ..... |

EXHIBIT I.63: AREAS EXPOSED TO METHYLENE CHLORIDE FROM REGULATION 308 SOURCE EMISSIONS

H - 63

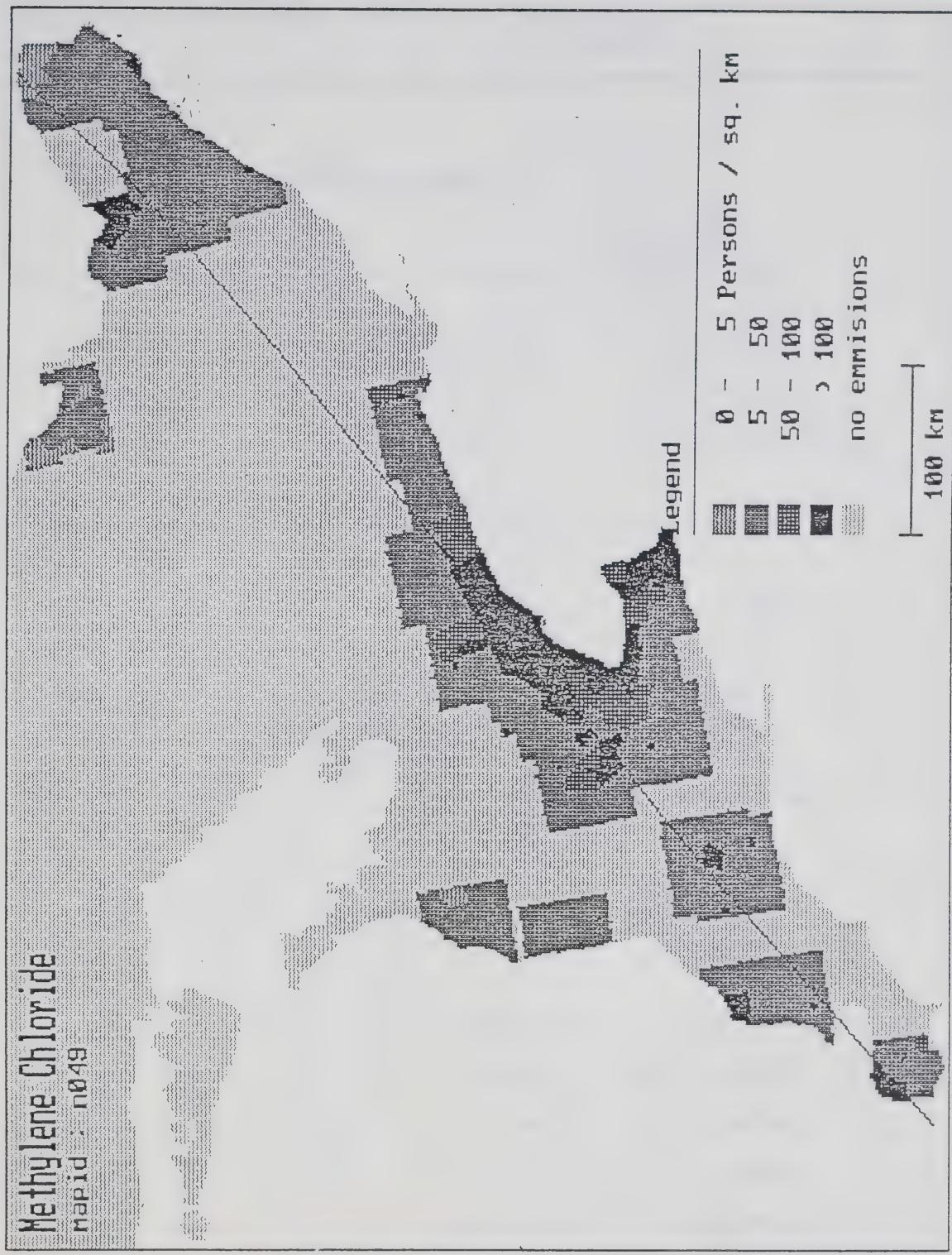
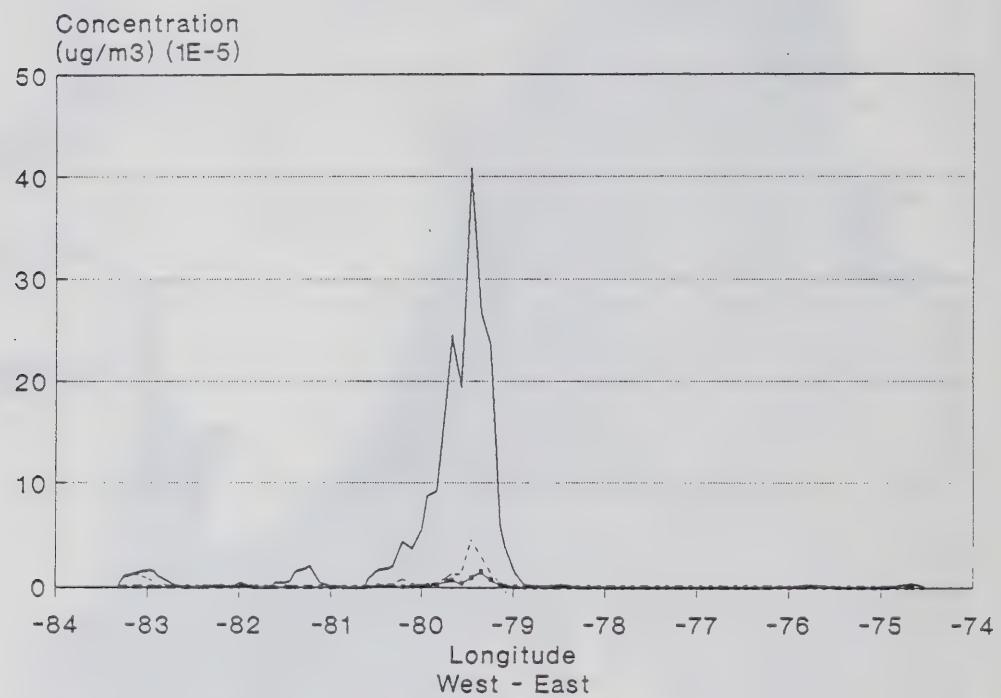


EXHIBIT I.64: PROFILE OF METHYLENE CHLORIDE CONCENTRATION DUE TO
REGULATION 308 SOURCE EMISSIONS ACROSS SOUTHERN
ONTARIO

Methylene Chloride



Legend

- | | |
|-----------------|-------|
| Existing | — |
| Scenarios A & D | — |
| Scenario B | — |
| Scenario C | ----- |
| Scenario E | ..... |

EXHIBIT I.65: AREAS EXPOSED TO NAPHTHALENE FROM REGULATION 308 SOURCE EMISSIONS

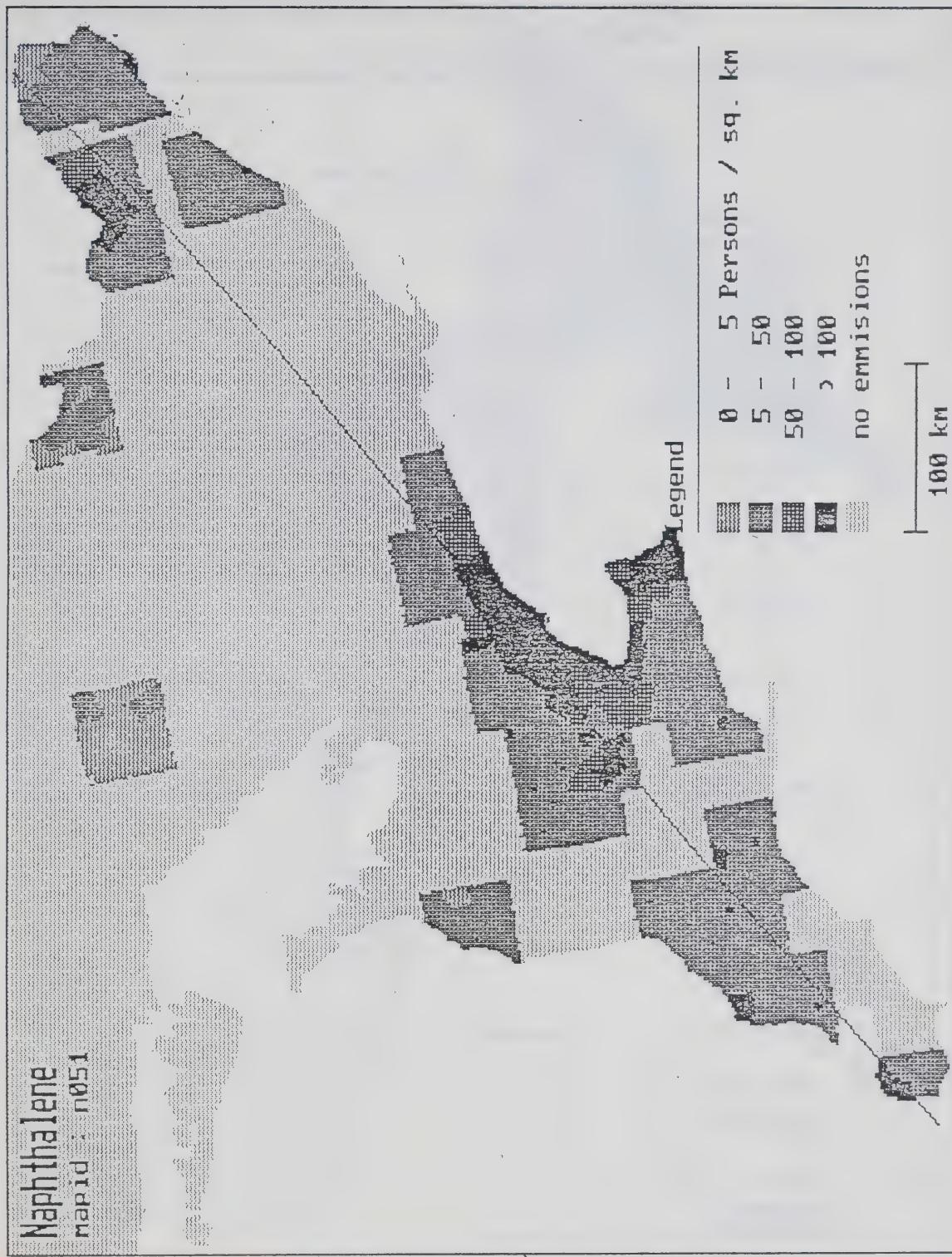
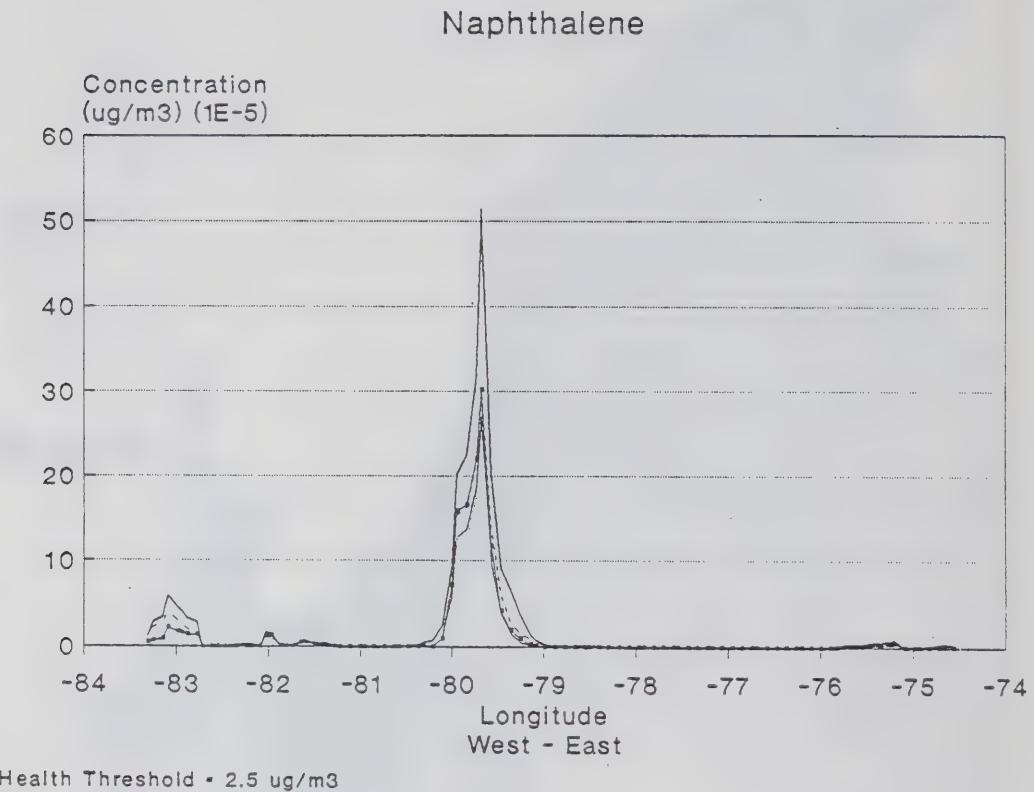


EXHIBIT I.66: PROFILE OF NAPHTHALENE CONCENTRATION DUE TO
REGULATION 308 SOURCE EMISSIONS ACROSS SOUTHERN
ONTARIO



Legend

- | | |
|-----------------|-------|
| Existing | _____ |
| Scenarios A & D | _____ |
| Scenario B | _____ |
| Scenario C | ----- |
| Scenario E | ***** |

EXHIBIT I.67: AREAS EXPOSED TO NICKEL FROM REGULATION 308 SOURCE EMISSIONS

H - 67

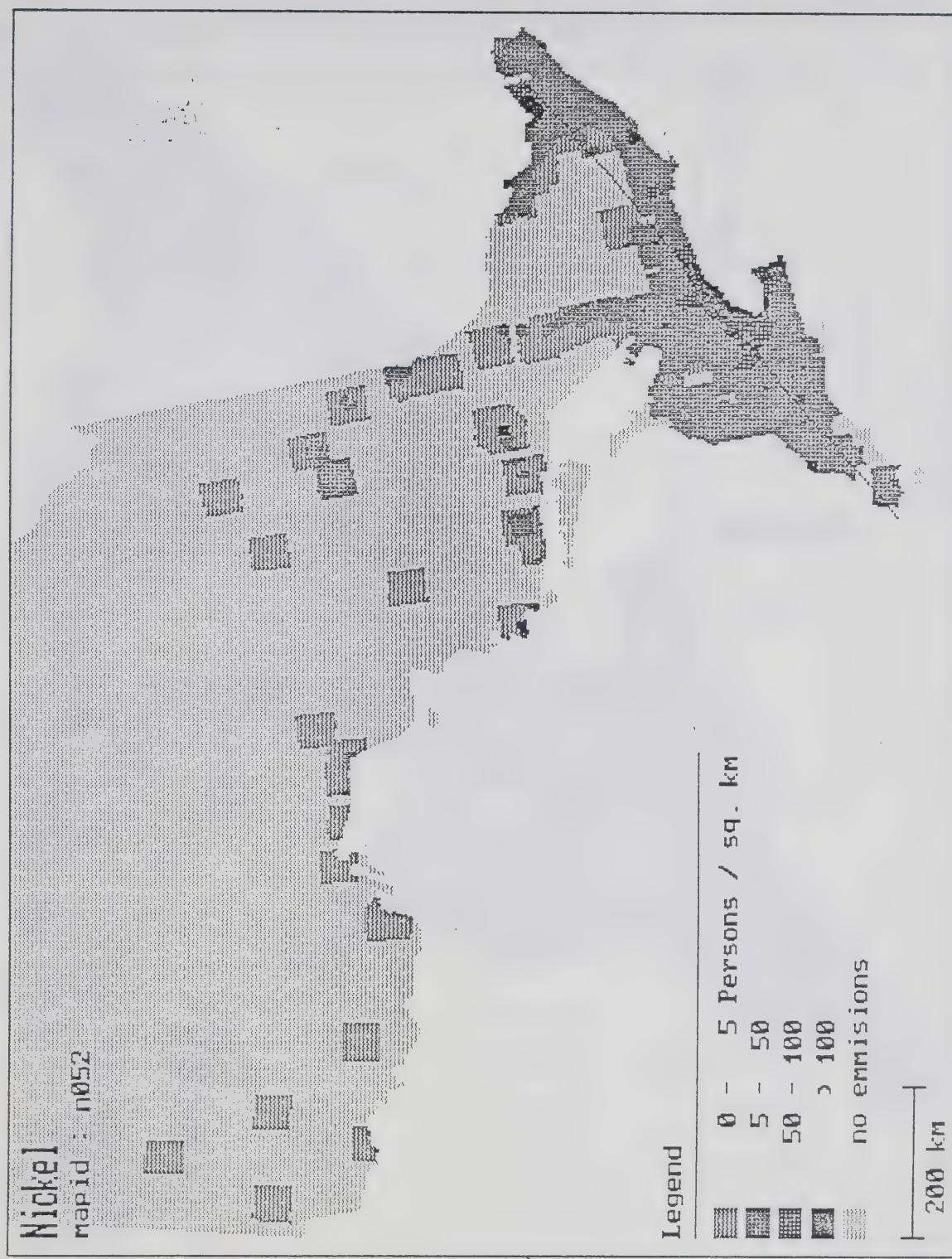
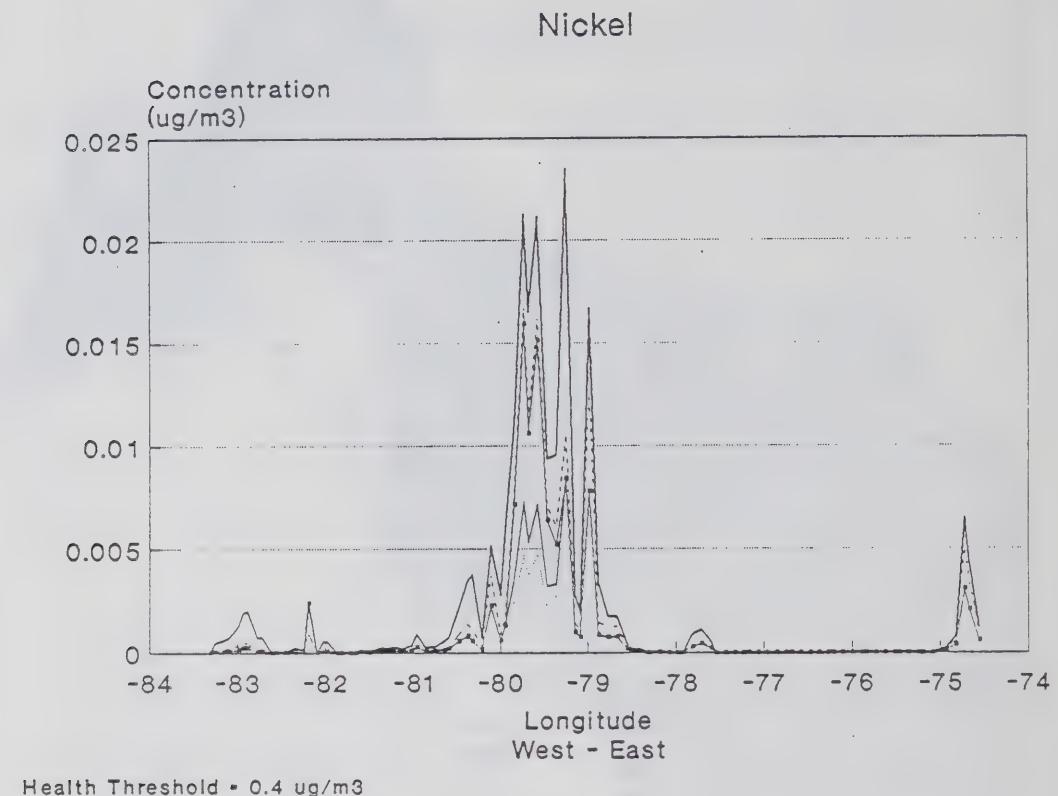


EXHIBIT I.68: PROFILE OF NICKEL CONCENTRATION DUE TO REGULATION
308 SOURCE EMISSIONS ACROSS SOUTHERN ONTARIO



Legend

- | | |
|-----------------|-----------|
| Existing | — |
| Scenarios A & D | — |
| Scenario B | — |
| Scenario C | ----- |
| Scenario E | · · · · · |

EXHIBIT I.69: AREAS EXPOSED TO NITROGEN OXIDES FROM REGULATION 308 SOURCE EMISSIONS

I - 69

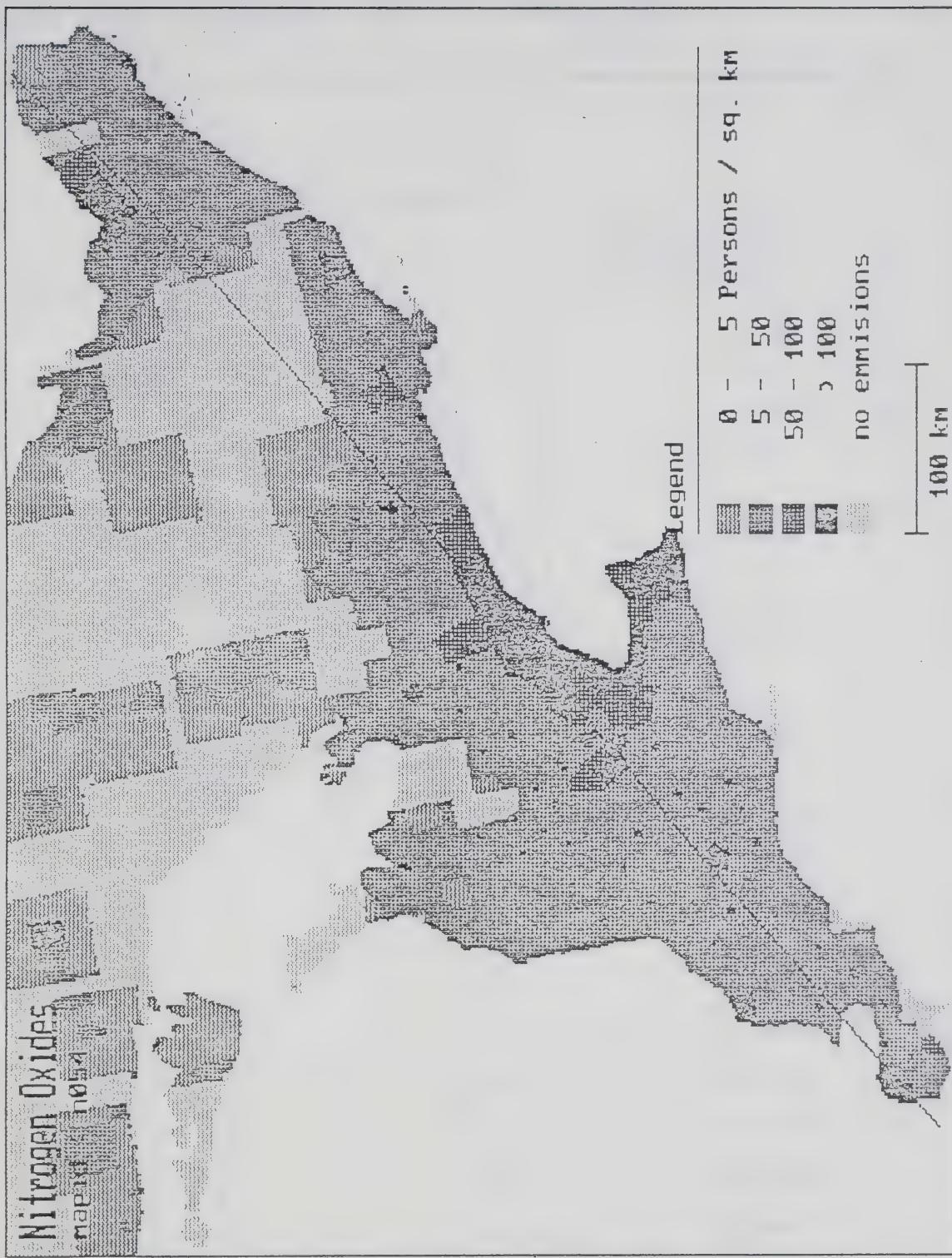
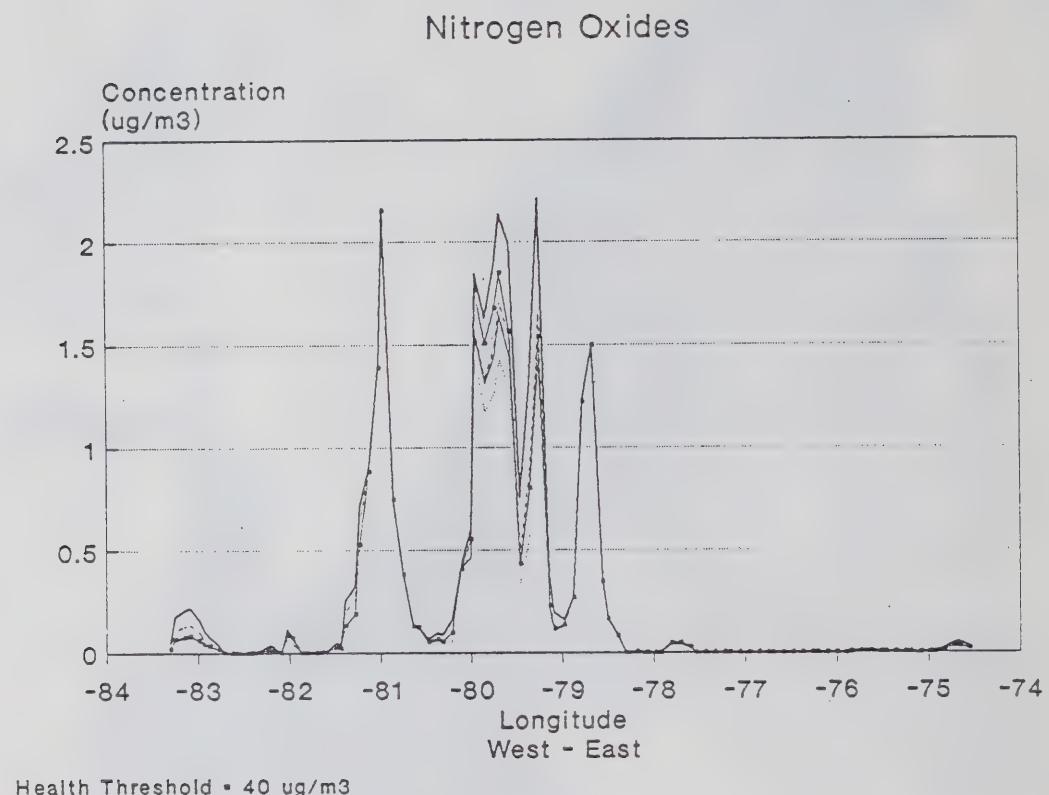


EXHIBIT I.70: PROFILE OF NITROGEN OXIDES CONCENTRATION DUE TO
REGULATION 308 SOURCE EMISSIONS ACROSS SOUTHERN
ONTARIO



Legend

- Existing _____
 - Scenarios A & D _____
 - Scenario B _____
 - Scenario C -----
 - Scenario E #####
-

EXHIBIT I.71: AREAS EXPOSED TO PERCHLOROETHYLENE FROM REGULATION 308 SOURCE EMISSIONS

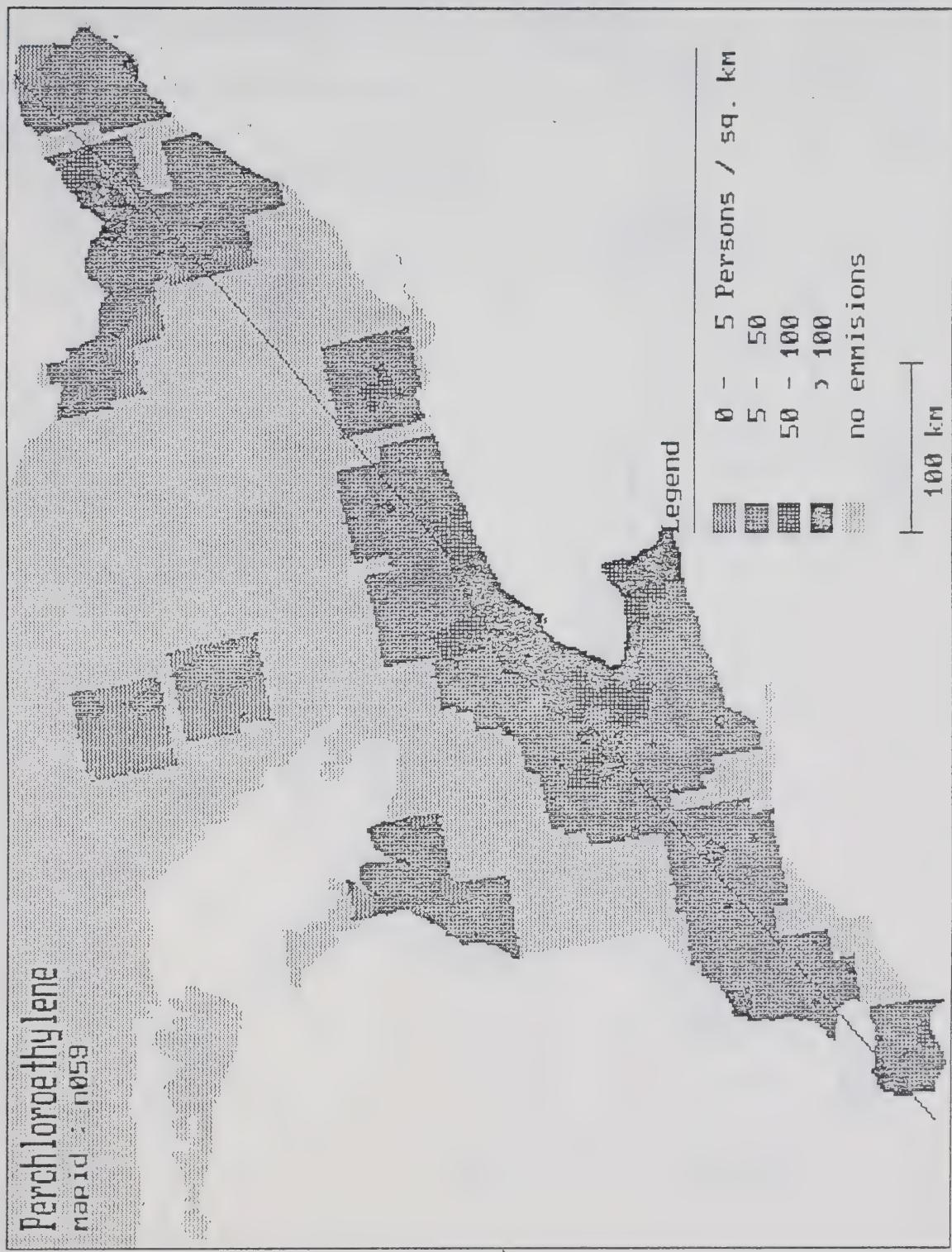
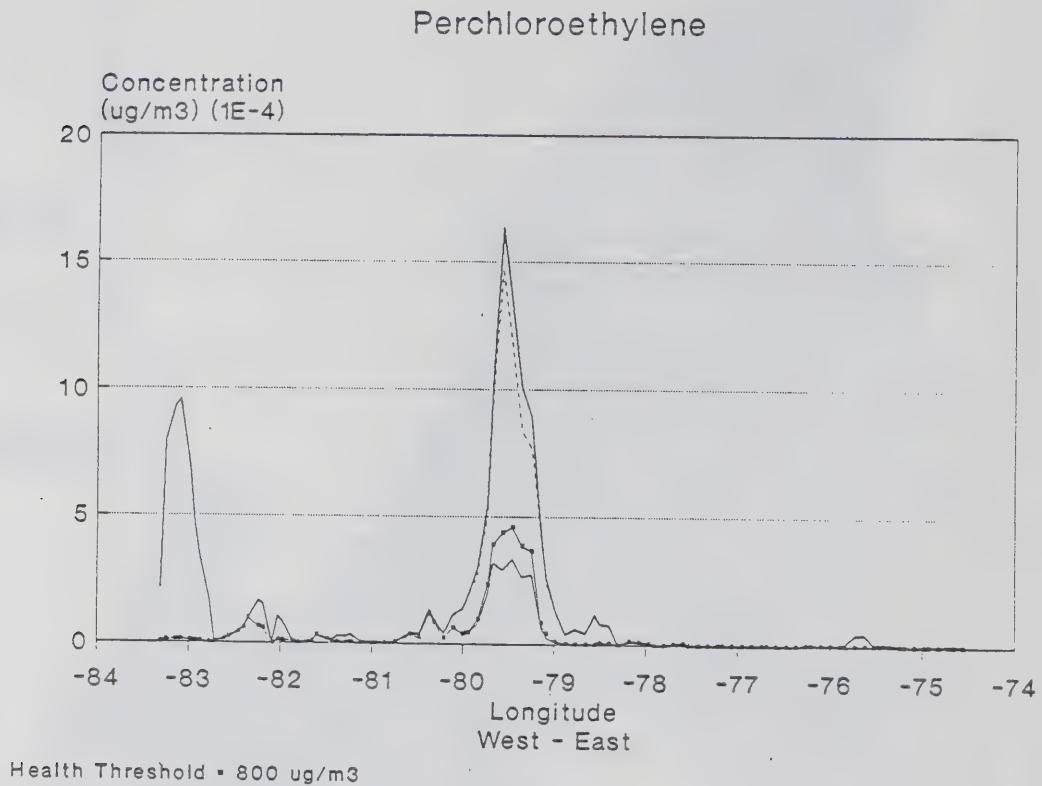


EXHIBIT I.72: PROFILE OF PERCHLOROETHYLENE CONCENTRATION DUE TO REGULATION 308 SOURCE EMISSIONS ACROSS SOUTHERN ONTARIO



Legend

- | | |
|-----------------|-------|
| Existing | — |
| Scenarios A & D | — |
| Scenario B | — |
| Scenario C | ----- |
| Scenario E | ..... |
-

EXHIBIT I.73: AREAS EXPOSED TO PHENOL FROM REGULATION 308 SOURCE EMISSIONS

I - 73

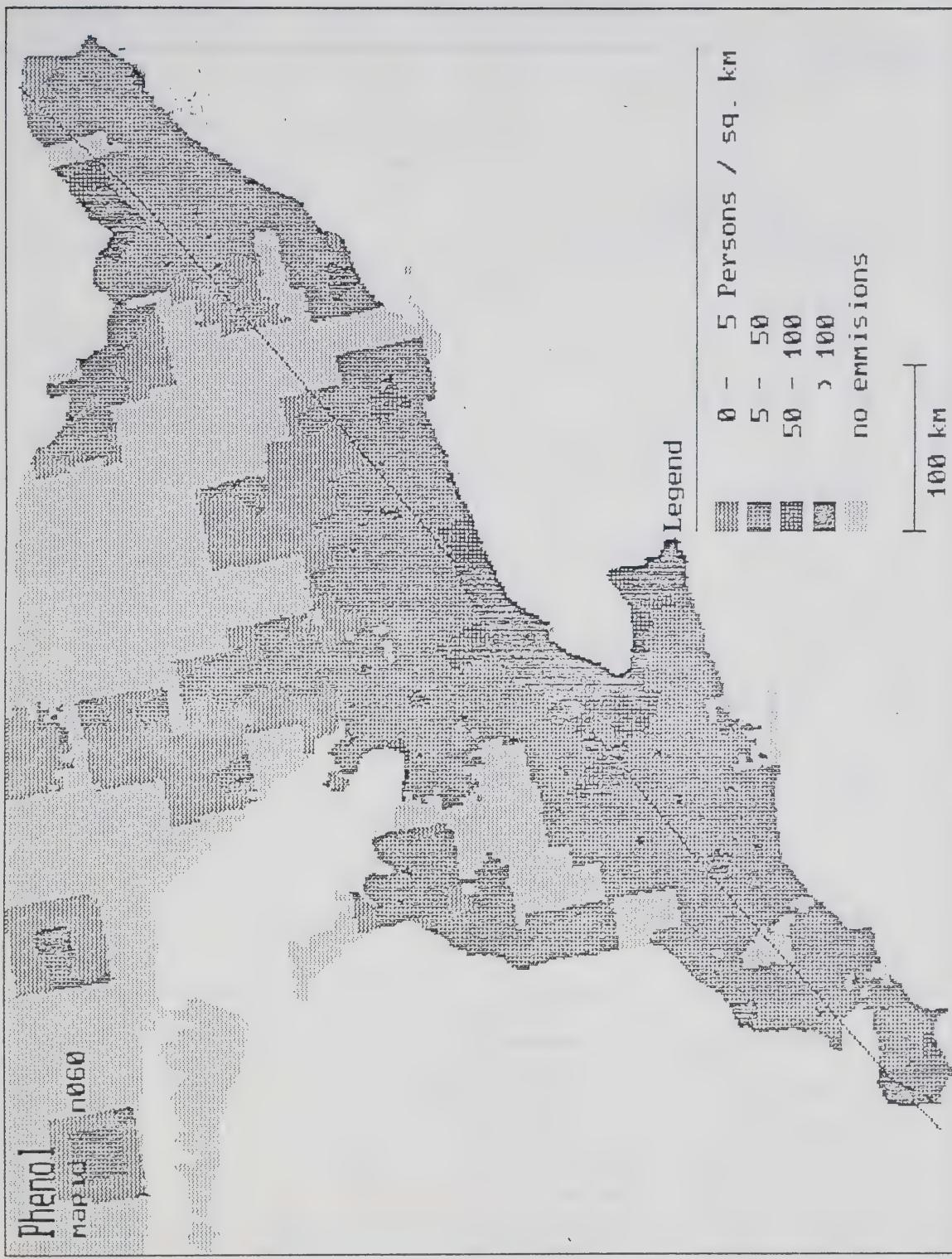
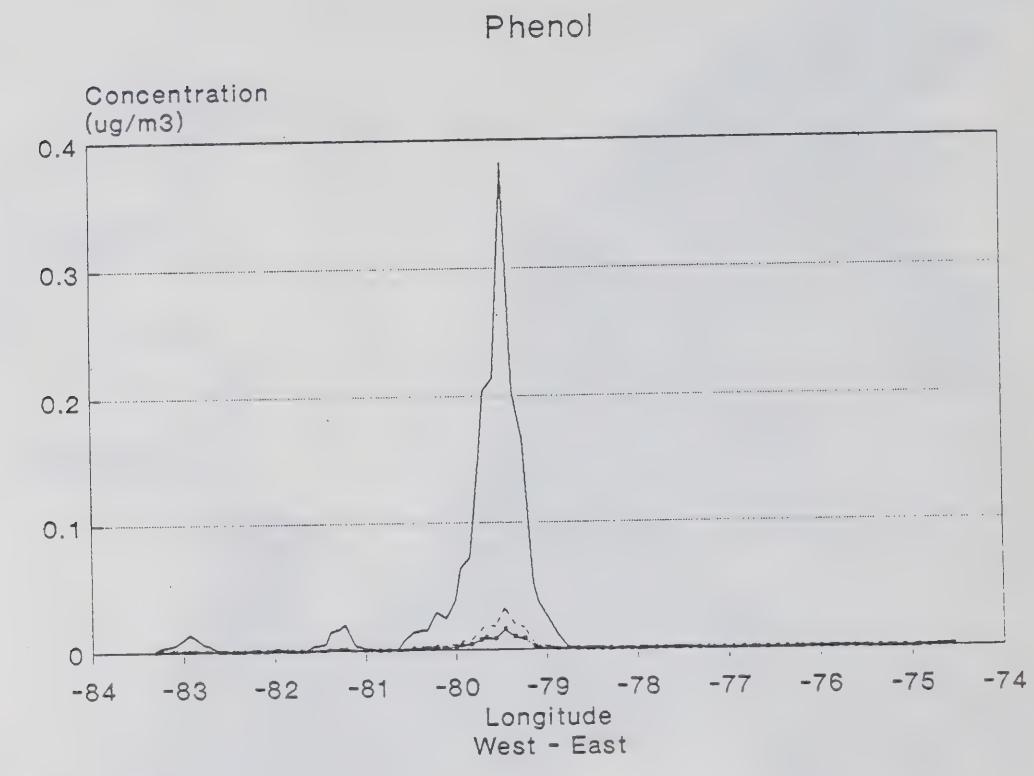


EXHIBIT I.74: PROFILE OF PHENOL CONCENTRATION DUE TO REGULATION
308 SOURCE EMISSIONS ACROSS SOUTHERN ONTARIO



Legend

Existing	_____
Scenarios A & D	_____
Scenario B	_____
Scenario C	-----
Scenario E	*****

EXHIBIT I.75: AREAS EXPOSED TO POLYCHLORINATED BIIPHENYLS FROM REGULATION 308
SOURCE EMISSIONS

I - 75

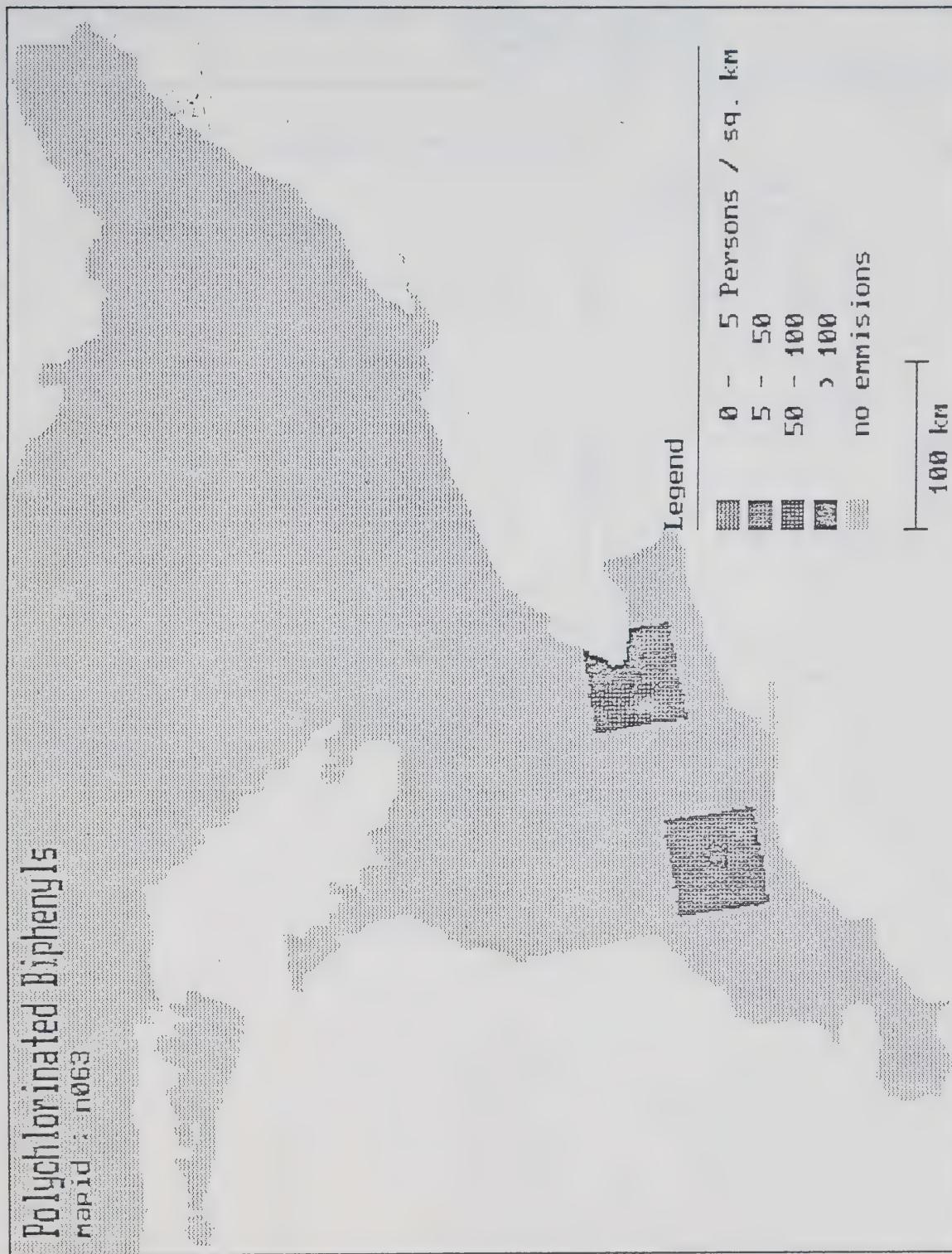
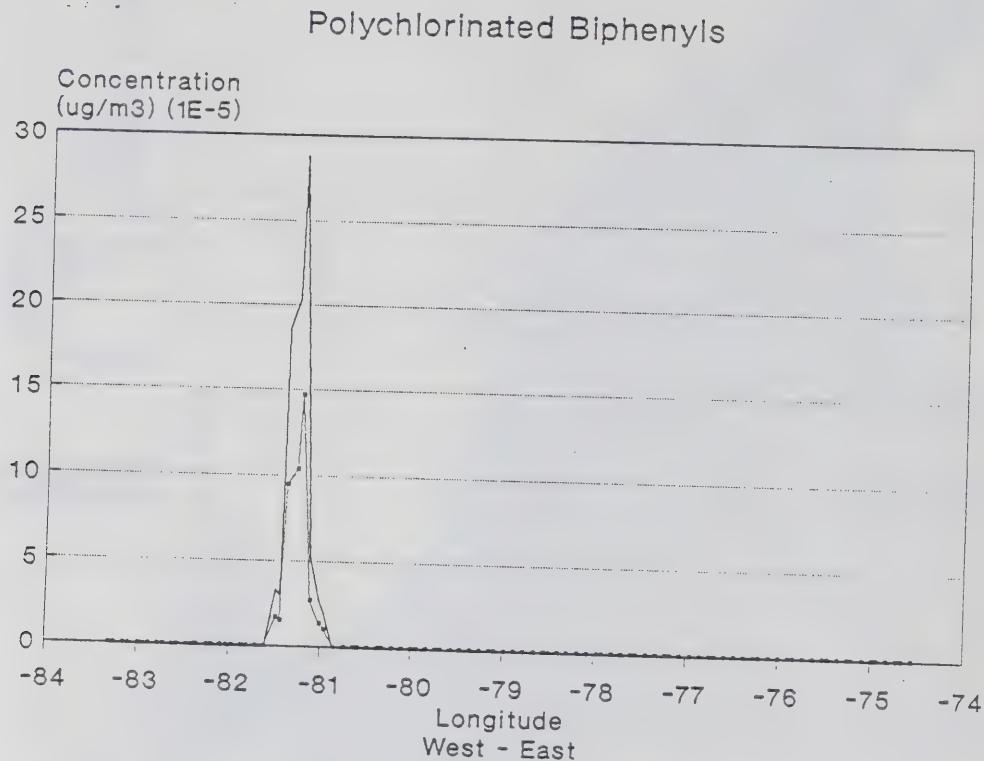


EXHIBIT I.76: PROFILE OF POLYCHLORINATED BIPHENYLS CONCENTRATION
DUE TO REGULATION 308 SOURCE EMISSIONS ACROSS
SOUTHERN ONTARIO



Health Threshold = 0.03 $\mu\text{g}/\text{m}^3$

Legend

- Existing _____
 - Scenarios A & D _____
 - Scenario B _____
 - Scenario C _____
 - Scenario E _____
-

EXHIBIT I.77: AREAS EXPOSED TO PROPIONALDEHYDE FROM REGULATION 308 SOURCE EMISSIONS

I - 77

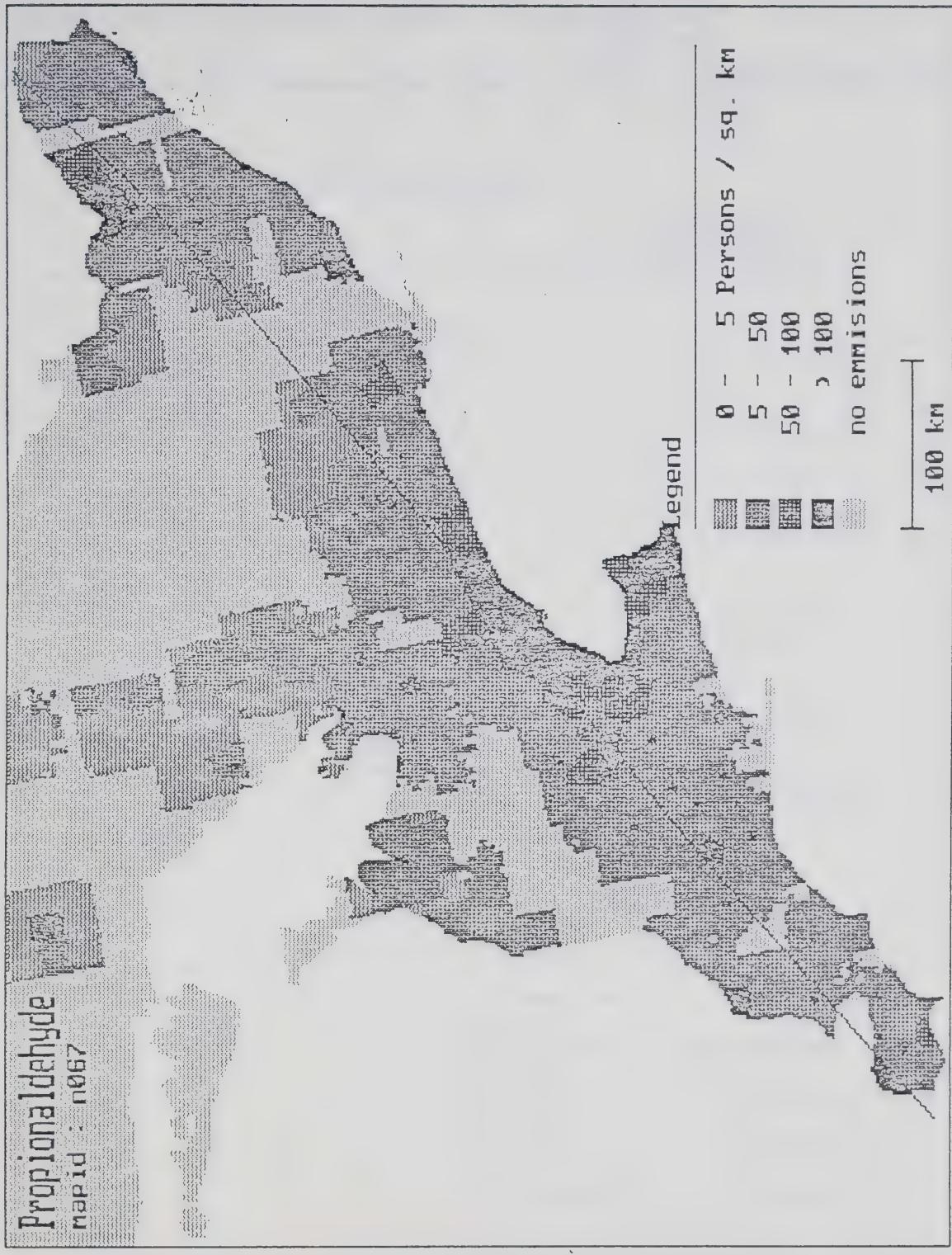
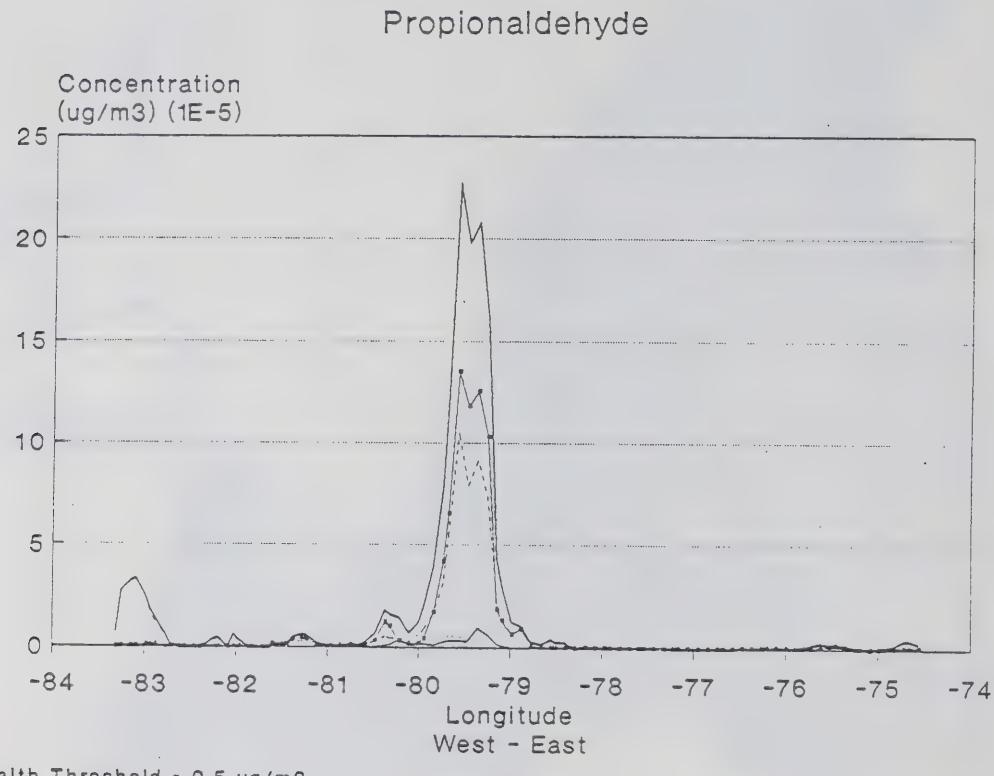


EXHIBIT I.78: PROFILE OF PROPIONALDEHYDE CONCENTRATION DUE TO REGULATION 308 SOURCE EMISSIONS ACROSS SOUTHERN ONTARIO



Legend

- | | |
|-----------------|-------|
| Existing | — |
| Scenarios A & D | — |
| Scenario B | — |
| Scenario C | · · · |
| Scenario E | — · — |

EXHIBIT I.79: AREAS EXPOSED TO PROPIONIC ACID FROM REGULATION 308 SOURCE EMISSIONS

I - 79

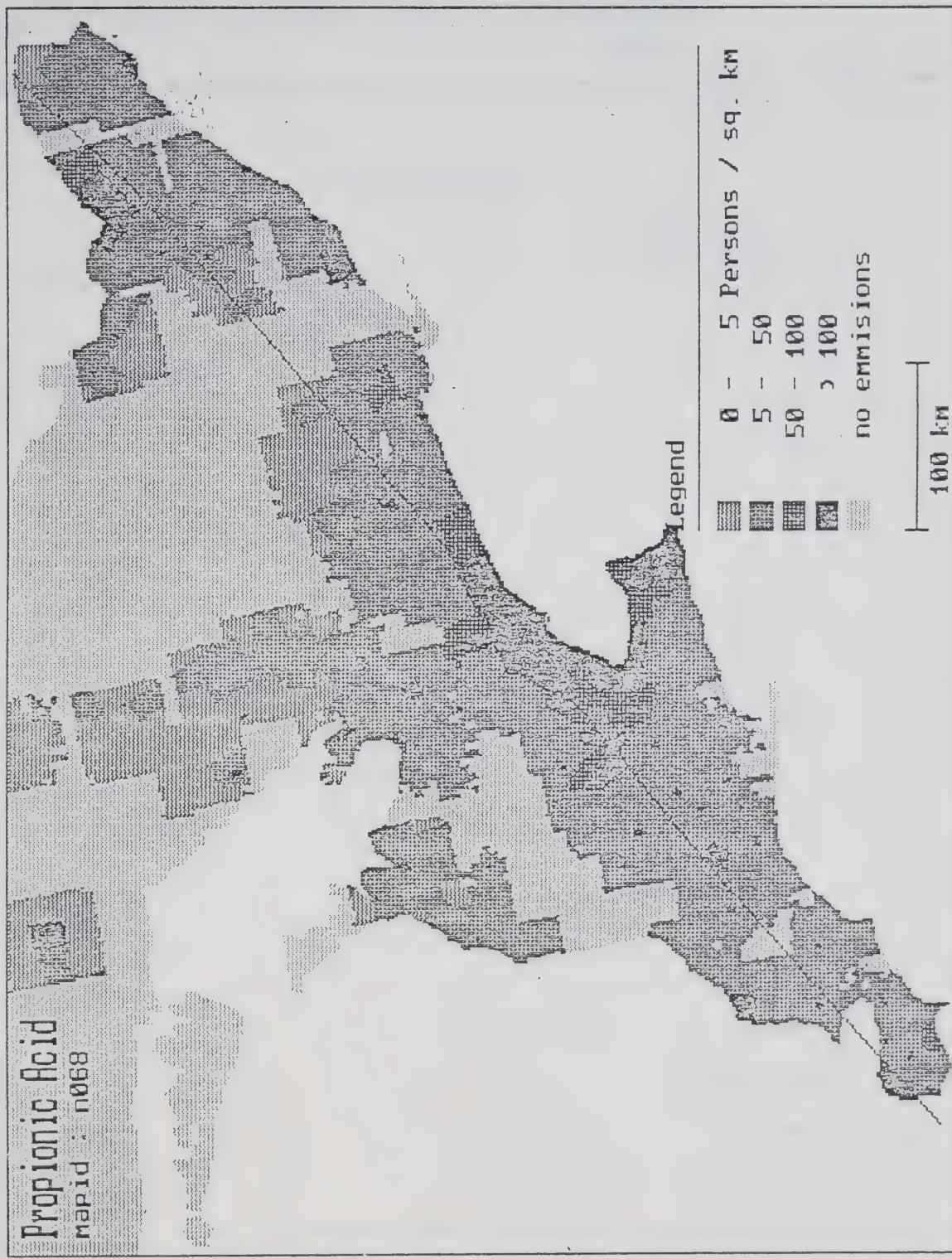
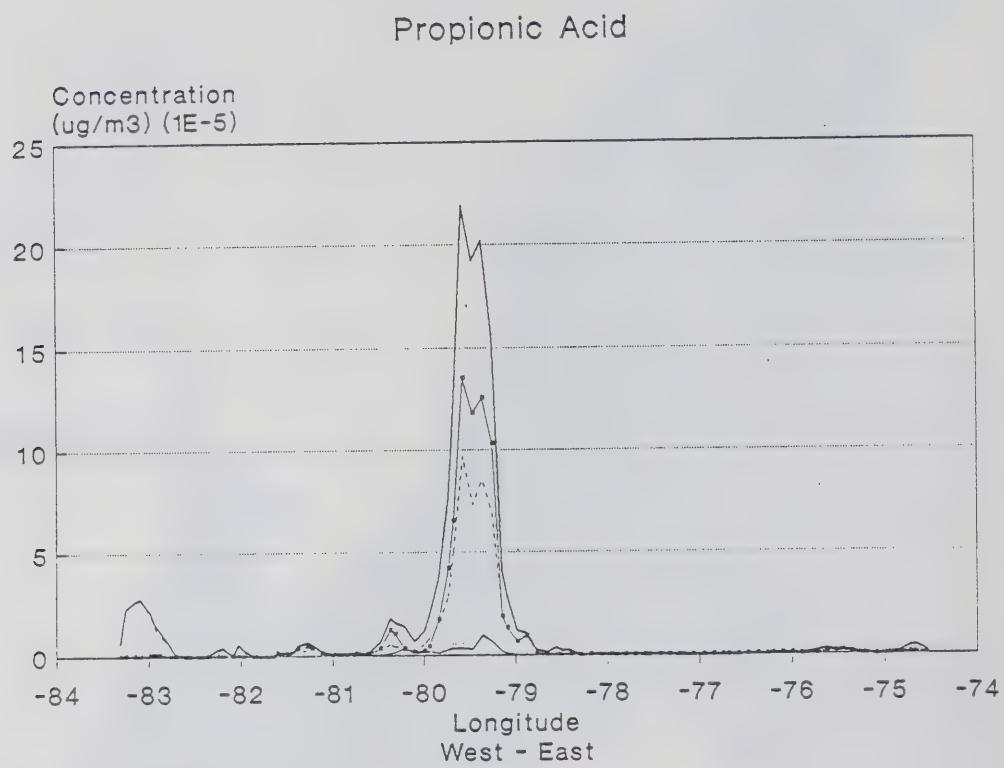


EXHIBIT I.80: PROFILE OF PROPIONIC ACID CONCENTRATION DUE TO
REGULATION 308 SOURCE EMISSIONS ACROSS SOUTHERN
ONTARIO



Legend

- Existing _____
- Scenarios A & D _____
- Scenario B _____
- Scenario C -----
- Scenario E #####

EXHIBIT I.81: AREAS EXPOSED TO PROPYLENE OXIDE FROM REGULATION 308 SOURCE EMISSIONS

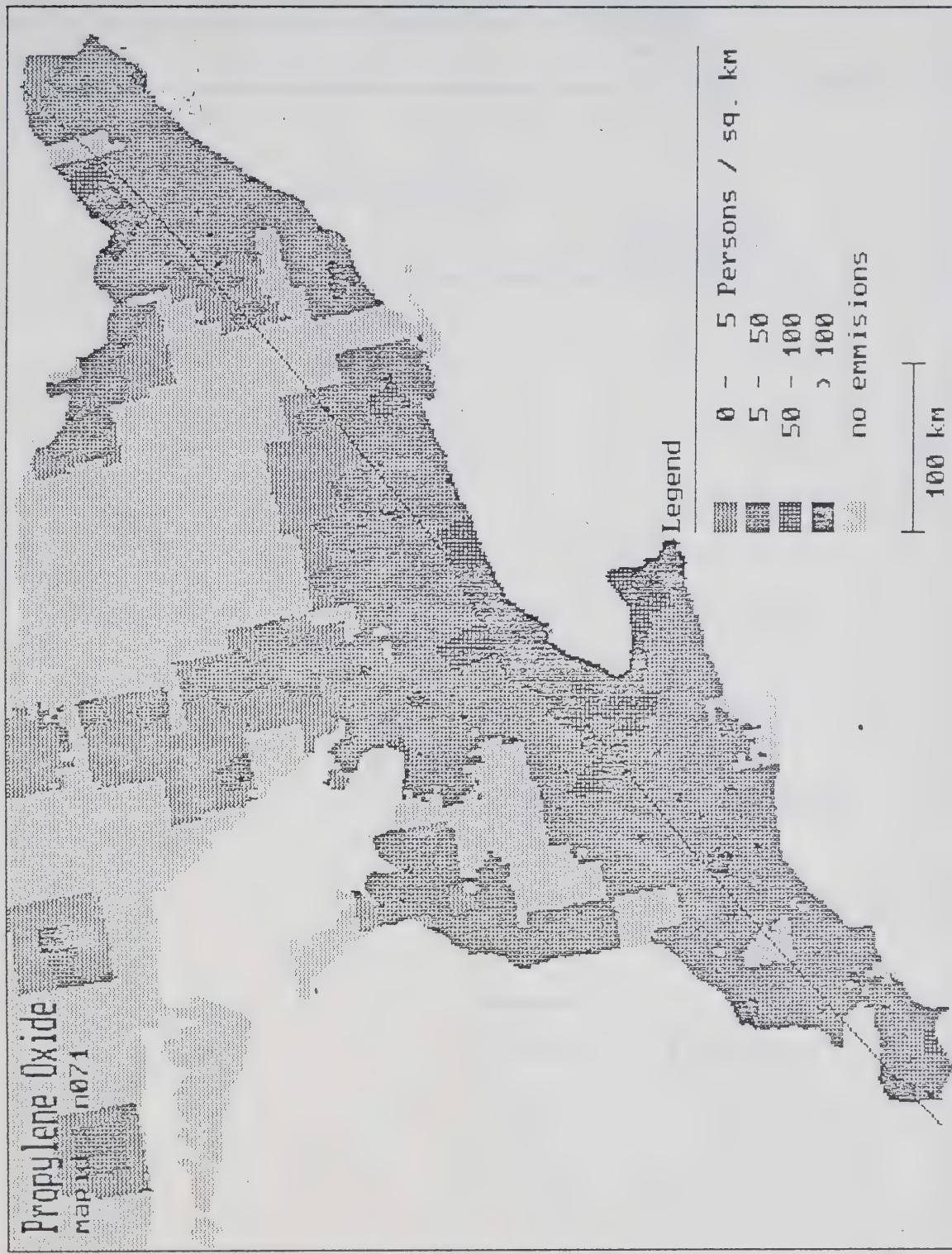
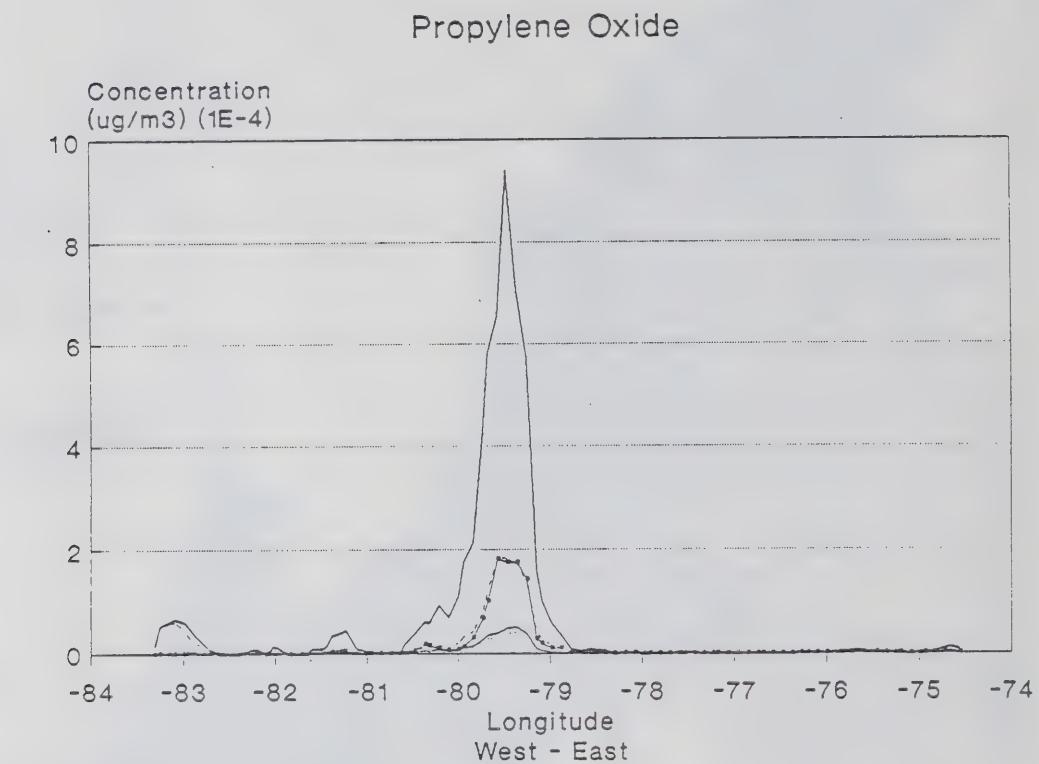


EXHIBIT I.82: PROFILE OF PROPYLENE OXIDE CONCENTRATION DUE TO REGULATION 308 SOURCE EMISSIONS ACROSS SOUTHERN ONTARIO



Legend

- | | |
|-----------------|-----------|
| Existing | — |
| Scenarios A & D | - - - |
| Scenario B | - · - |
| Scenario C | · - - - |
| Scenario E | · - - - - |

EXHIBIT I.83: AREAS EXPOSED TO SELENIUM FROM REGULATION 308 SOURCE EMISSIONS

H - 83

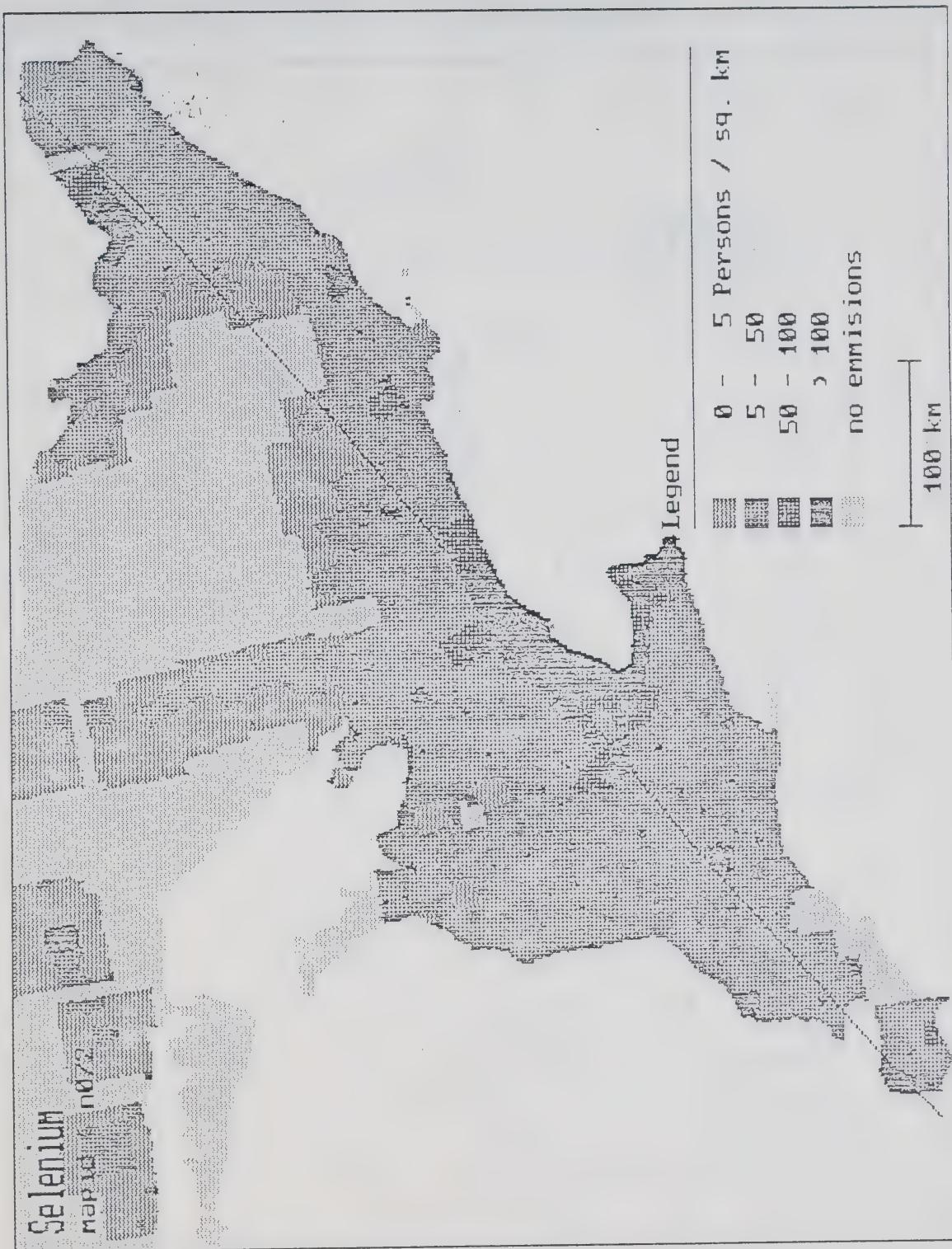
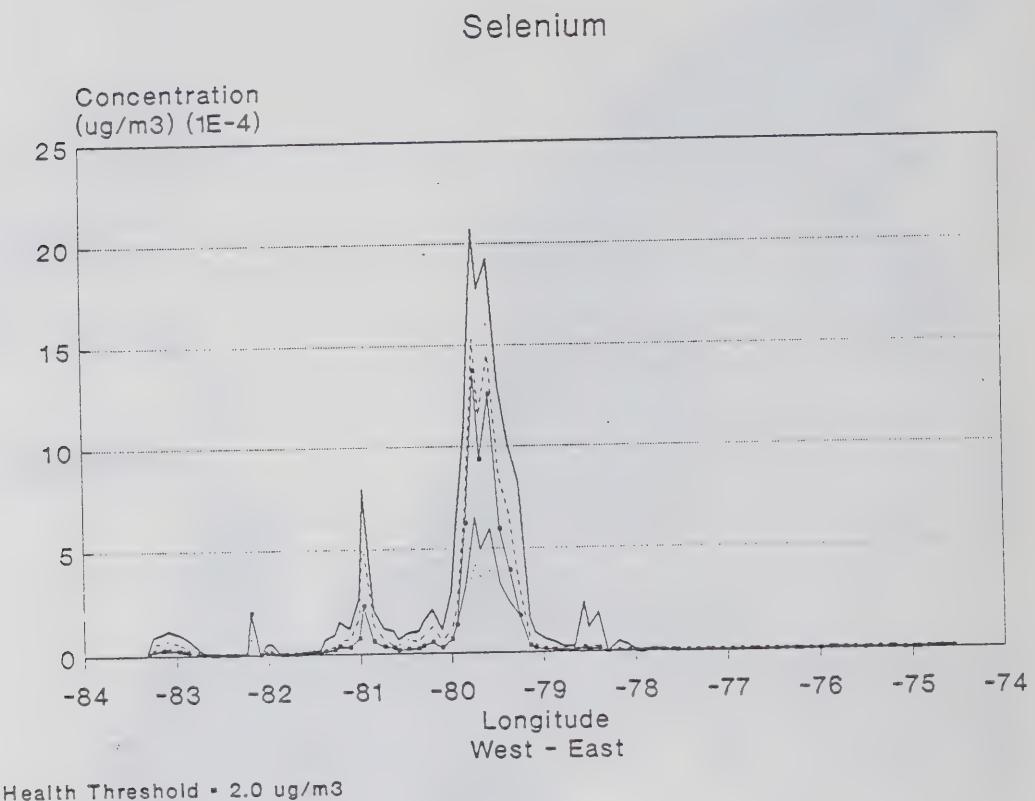


EXHIBIT I.84: PROFILE OF SELENIUM CONCENTRATION DUE TO REGULATION
308 SOURCE EMISSIONS ACROSS SOUTHERN ONTARIO



Legend

- | | |
|-----------------|-------|
| Existing | — |
| Scenarios A & D | - - - |
| Scenario B | — |
| Scenario C | ----- |
| Scenario E | ..... |

EXHIBIT I.85: AREAS EXPOSED TO SILICA FROM REGULATION 308 SOURCE EMISSIONS

H - 85

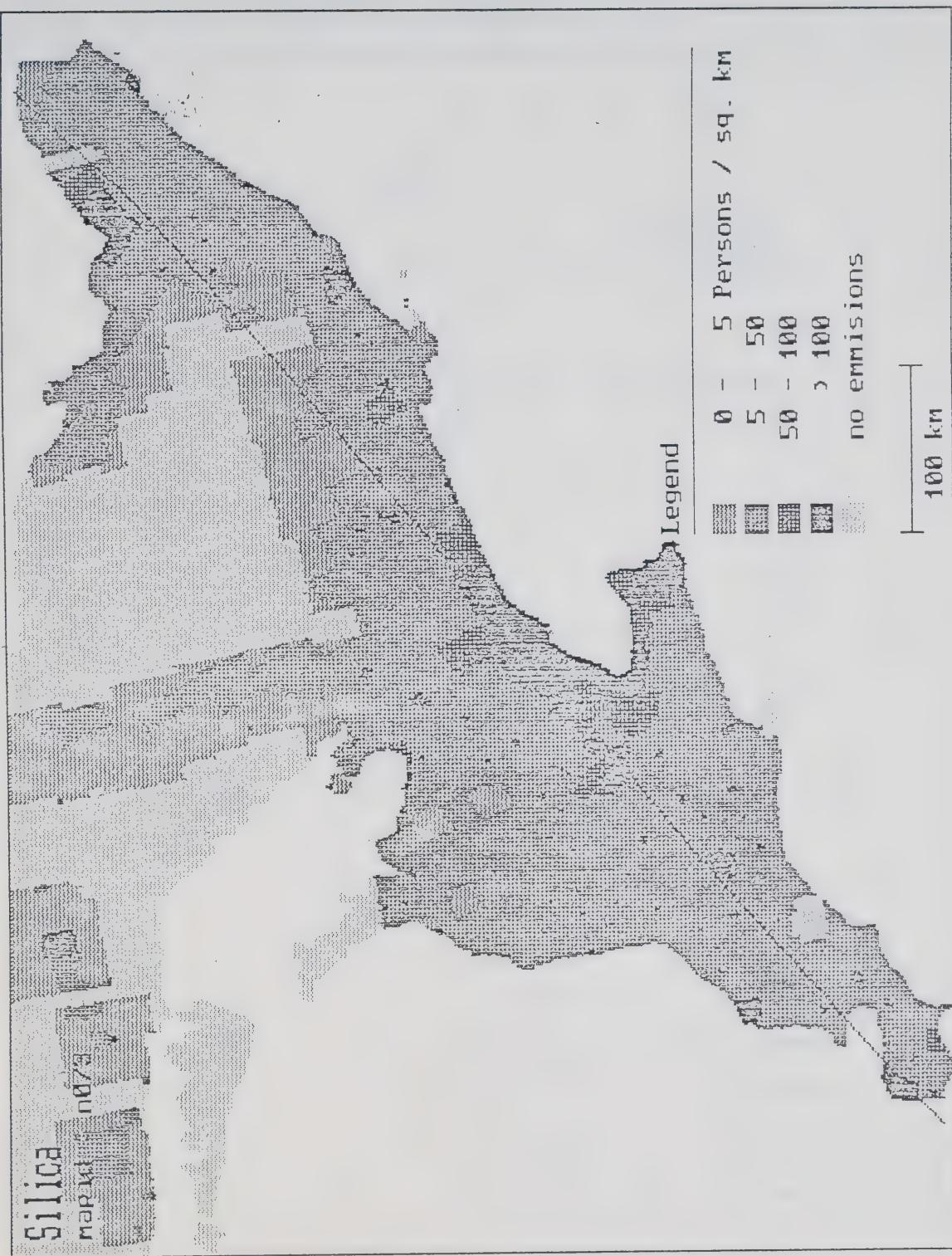
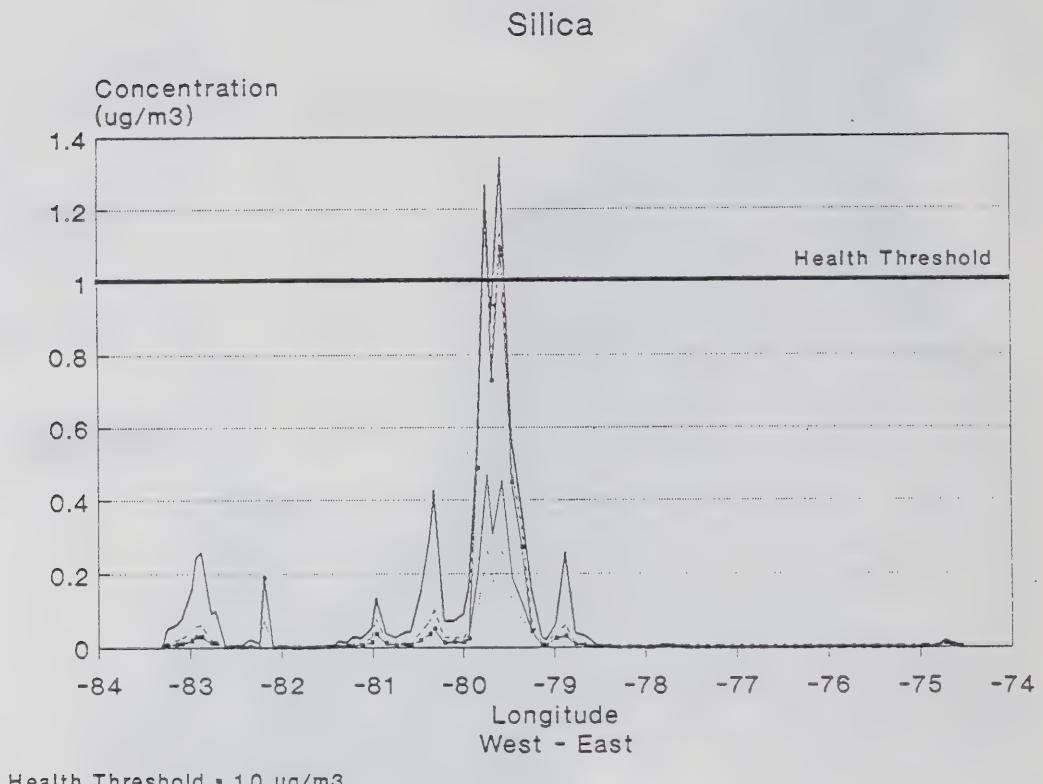


EXHIBIT I.86: PROFILE OF SILICA CONCENTRATION DUE TO REGULATION
308 SOURCE EMISSIONS ACROSS SOUTHERN ONTARIO



Legend

- | | |
|-----------------|-------|
| Existing | — |
| Scenarios A & D | --- |
| Scenario B | —·— |
| Scenario C | ···· |
| Scenario E | ····· |

EXHIBIT I.87: AREAS EXPOSED TO STYRENE FROM REGULATION 308 SOURCE EMISSIONS

H - 87

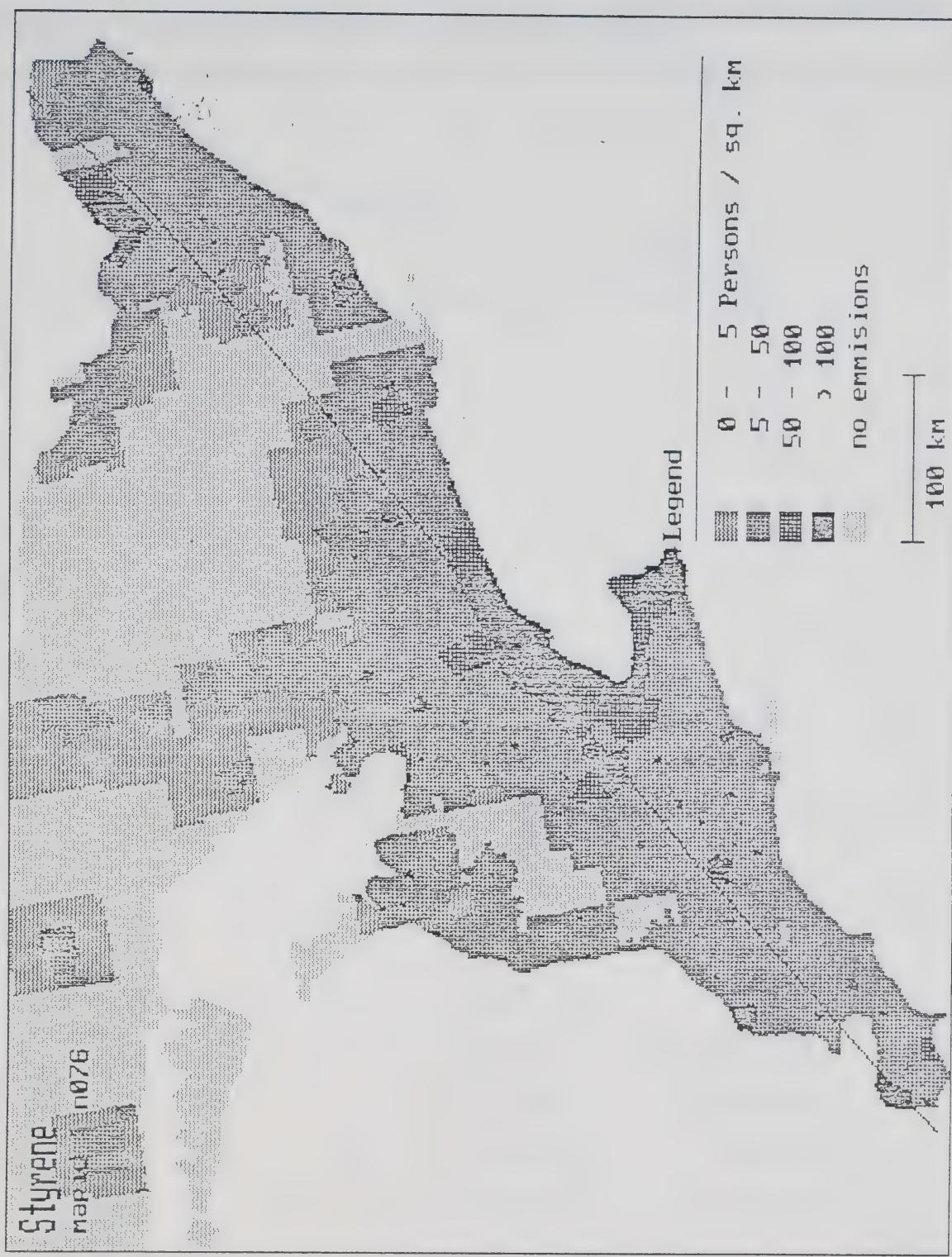
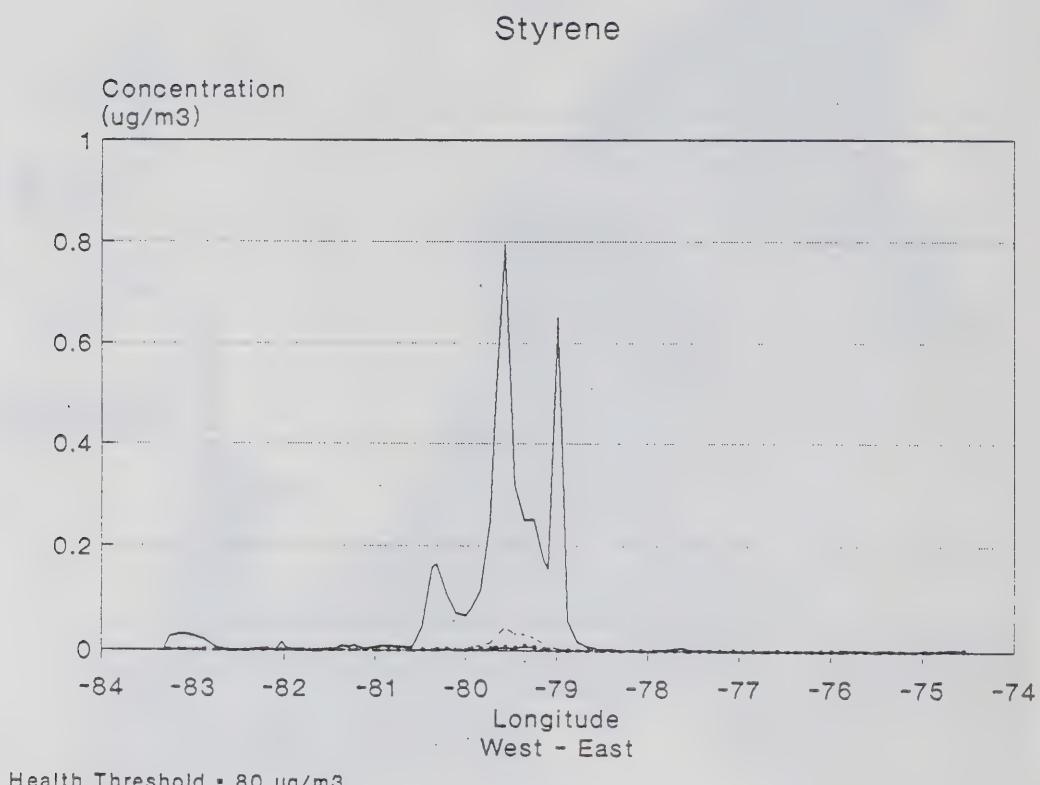


EXHIBIT I.88: PROFILE OF STYRENE CONCENTRATION DUE TO REGULATION
308 SOURCE EMISSIONS ACROSS SOUTHERN ONTARIO



Legend

Existing	—
Scenarios A & D	—
Scenario B	—
Scenario C	-----
Scenario E	*****

EXHIBIT I.89 : AREAS EXPOSED TO SULPHUR DIOXIDE FROM REGULATION 308 SOURCE EMISSIONS

I - 89

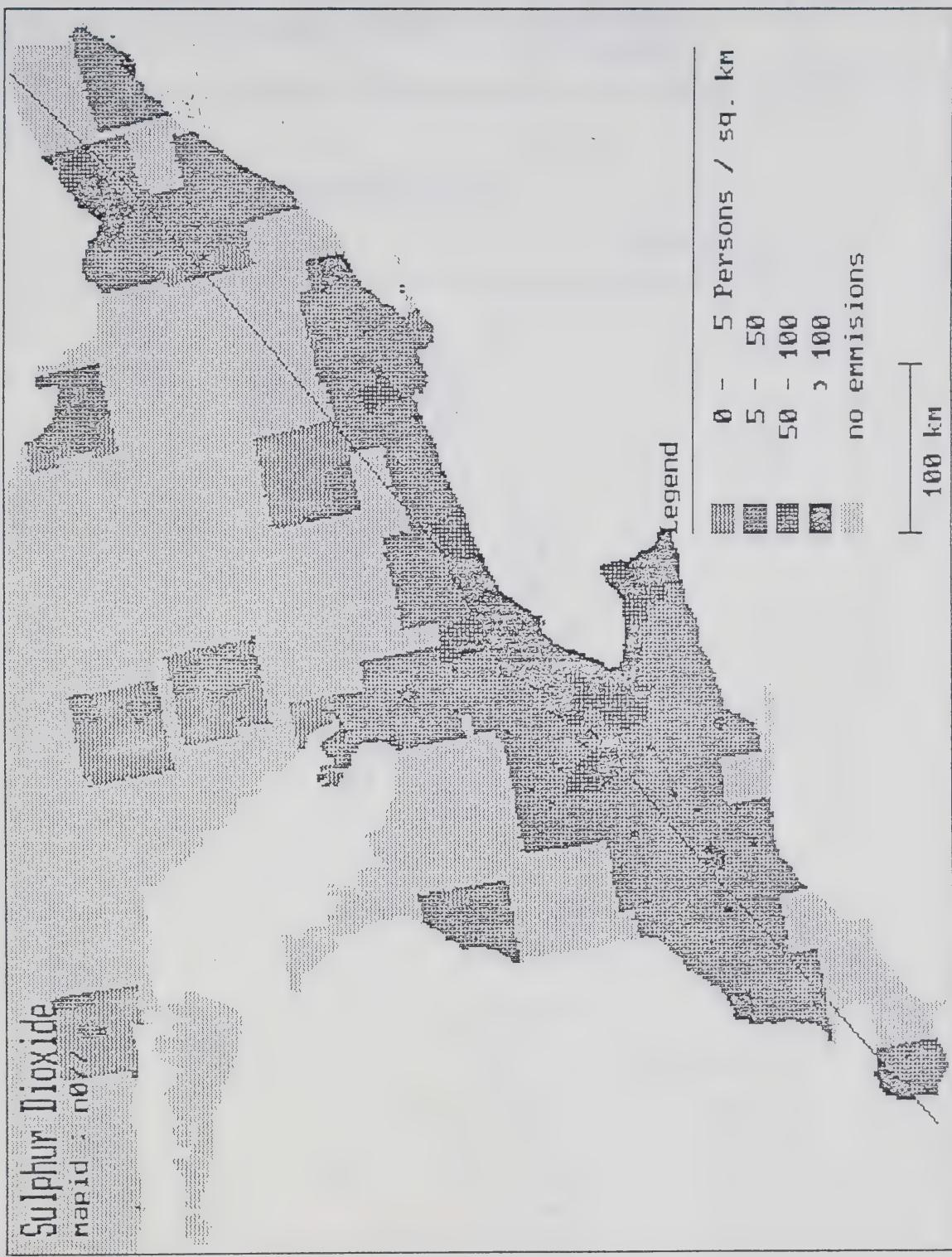
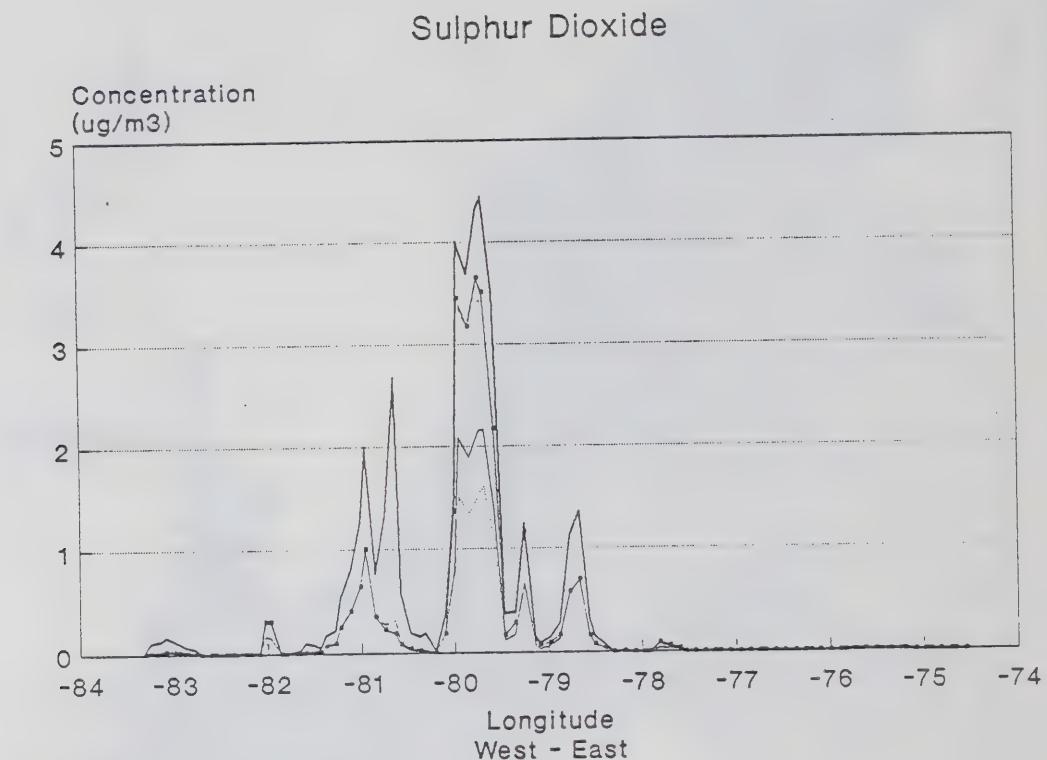


EXHIBIT I.90: PROFILE OF SULPHUR DIOXIDE CONCENTRATION DUE TO
REGULATION 308 SOURCE EMISSIONS ACROSS SOUTHERN
ONTARIO



Legend

- | | |
|-----------------|-------|
| Existing | — |
| Scenarios A & D | — |
| Scenario B | — |
| Scenario C | ----- |
| Scenario E | ***** |

EXHIBIT I.91: AREAS EXPOSED TO SUSPENDED PARTICULATE MATTER FROM REGULATION 308
SOURCE EMISSIONS

I - 91

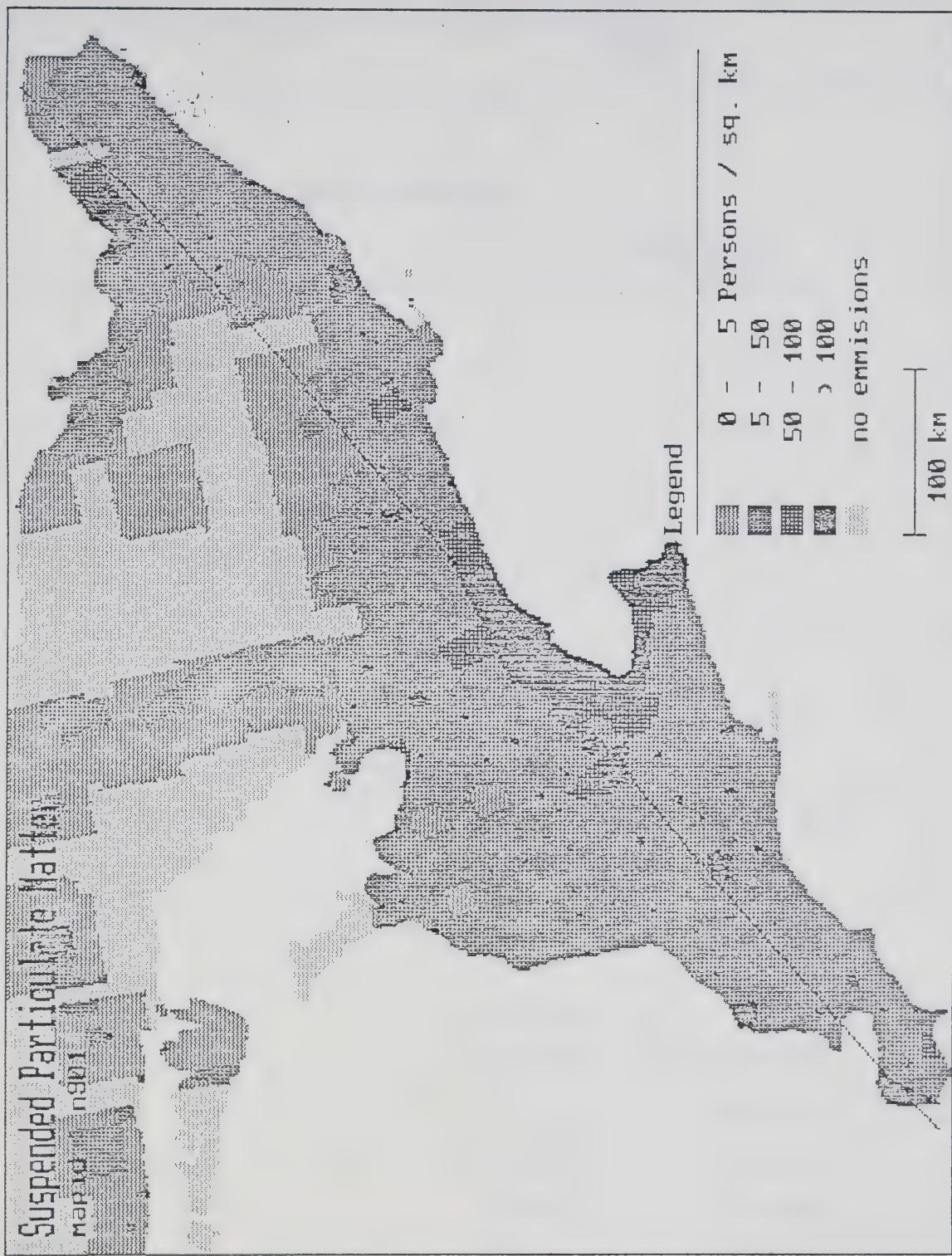
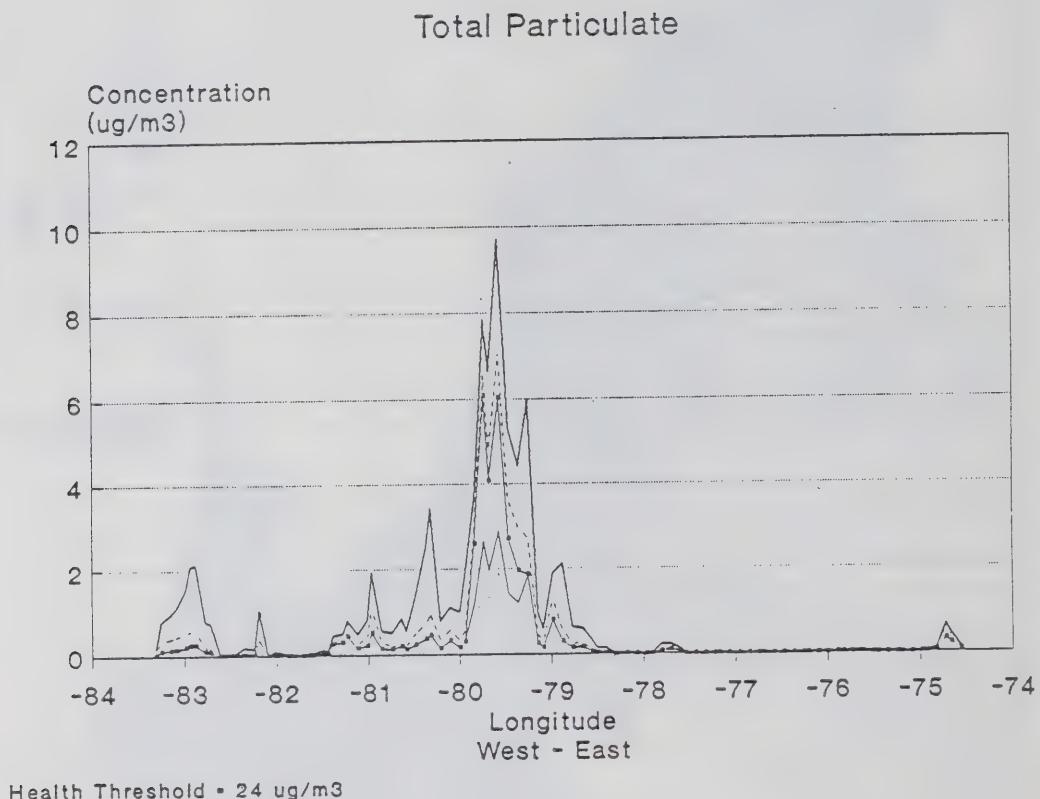


EXHIBIT I.92: PROFILE OF TOTAL PARTICULATE CONCENTRATION DUE TO
REGULATION 308 SOURCE EMISSIONS ACROSS SOUTHERN
ONTARIO



Legend

Existing	—
Scenarios A & D	—
Scenario B	—
Scenario C	----
Scenario E	=====

EXHIBIT I.93: AREAS EXPOSED TO TIN FROM REGULATION 308 SOURCE EMISSIONS

I - 93

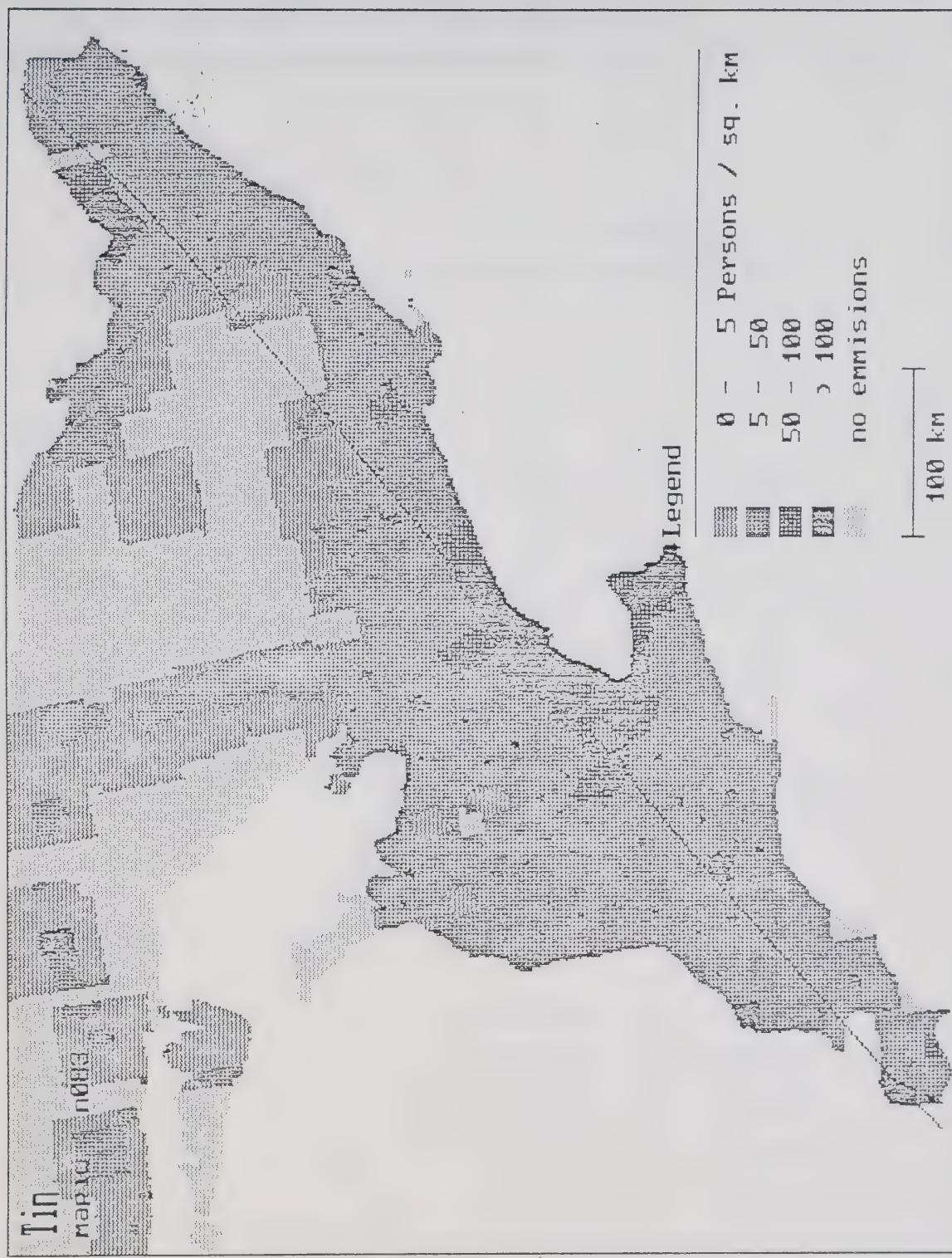
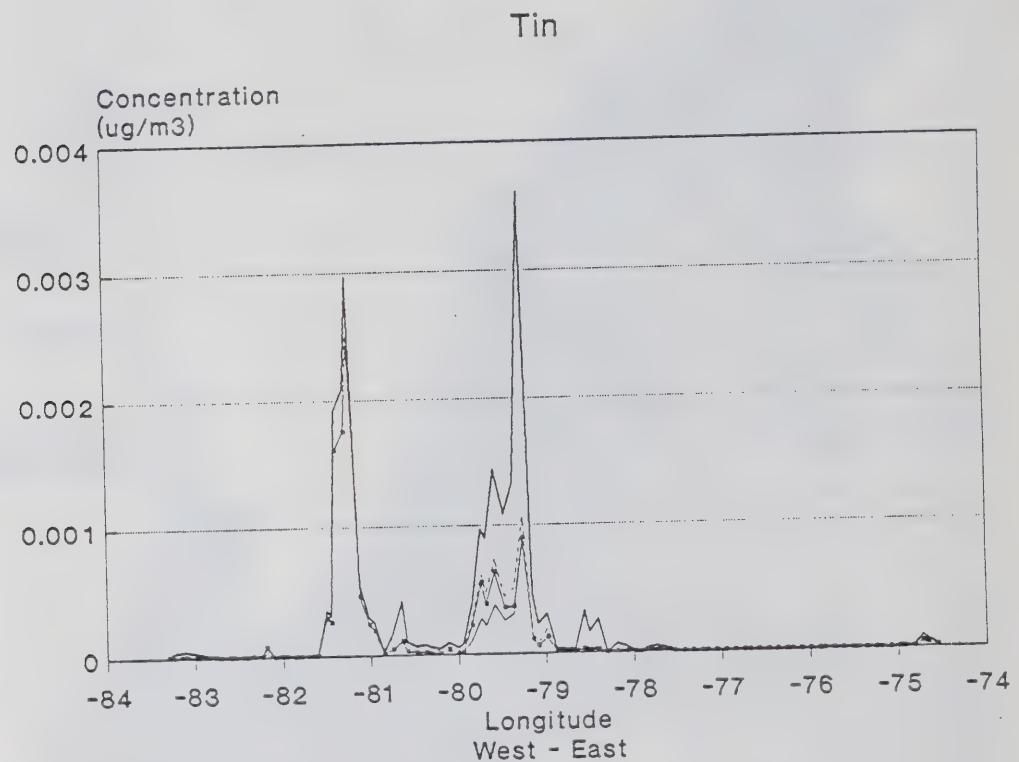


EXHIBIT I.94: PROFILE OF TIN CONCENTRATION DUE TO REGULATION 308
SOURCE EMISSIONS ACROSS SOUTHERN ONTARIO



Health Threshold = 2.0 $\mu\text{g}/\text{m}^3$

Legend

- | | |
|-----------------|-------|
| Existing | — |
| Scenarios A & D | — |
| Scenario B | — |
| Scenario C | ----- |
| Scenario E | ***** |

EXHIBIT I-95: AREAS EXPOSED TO TOLUENE FROM REGULATION 308 SOURCE EMISSIONS

I - 95

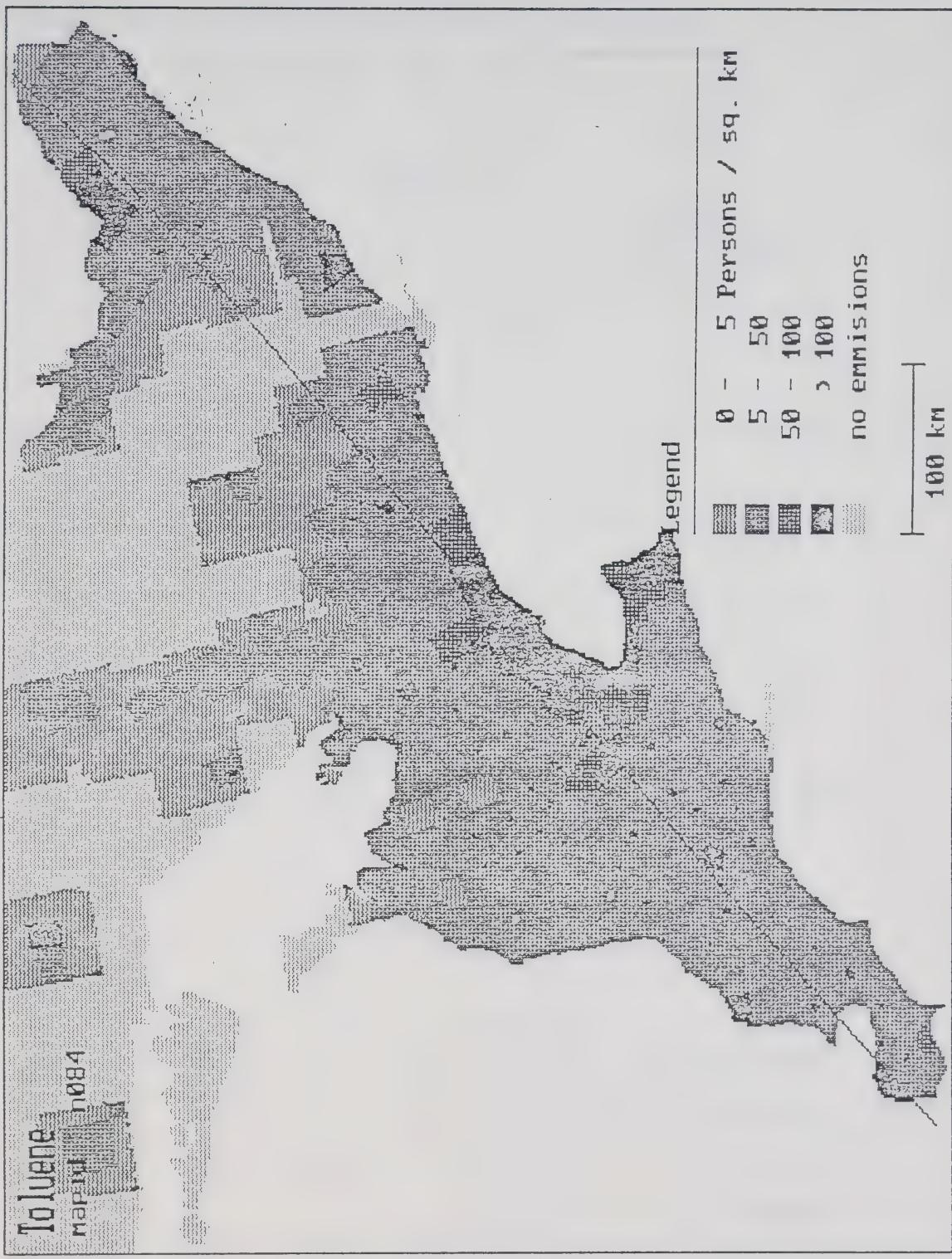
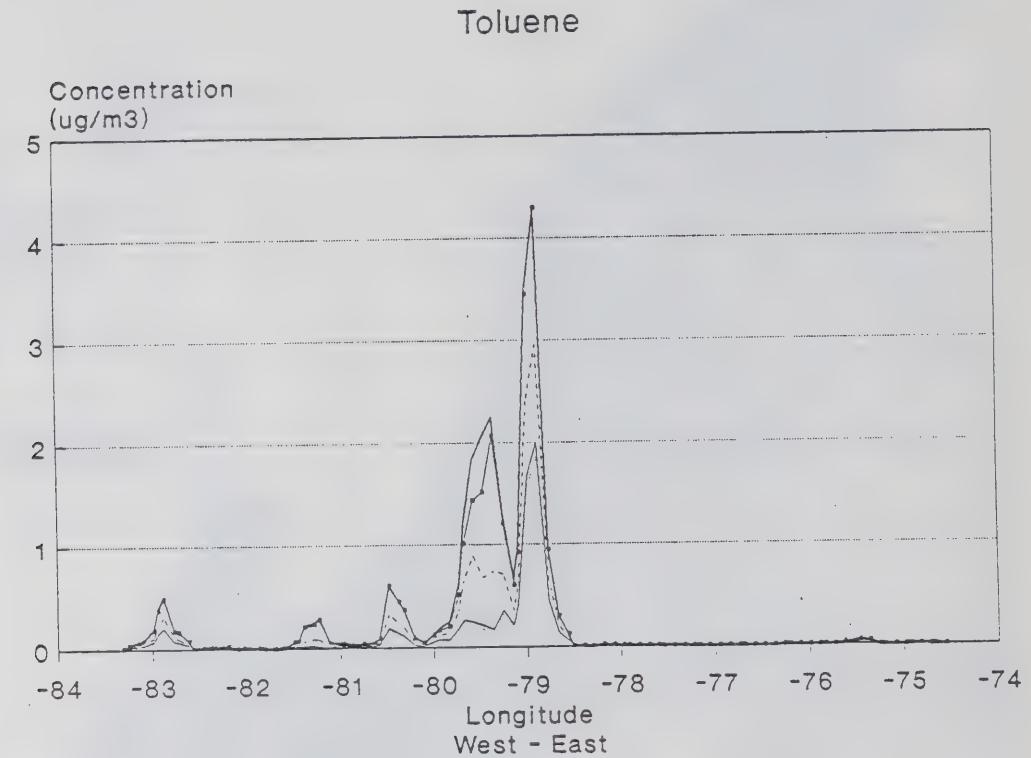


EXHIBIT I.96: PROFILE OF TOLUENE CONCENTRATION DUE TO REGULATION
308 SOURCE EMISSIONS ACROSS SOUTHERN ONTARIO



Health Threshold = 400 ug/m³

Legend

- | | |
|-----------------|--------|
| Existing | — |
| Scenarios A & D | --- |
| Scenario B | —·— |
| Scenario C | ·----- |
| Scenario E | ······ |

EXHIBIT I.97: AREAS EXPOSED TO TOLUENE DIISOCYANATE FROM REGULATION 308 SOURCE EMISSIONS

I - 97

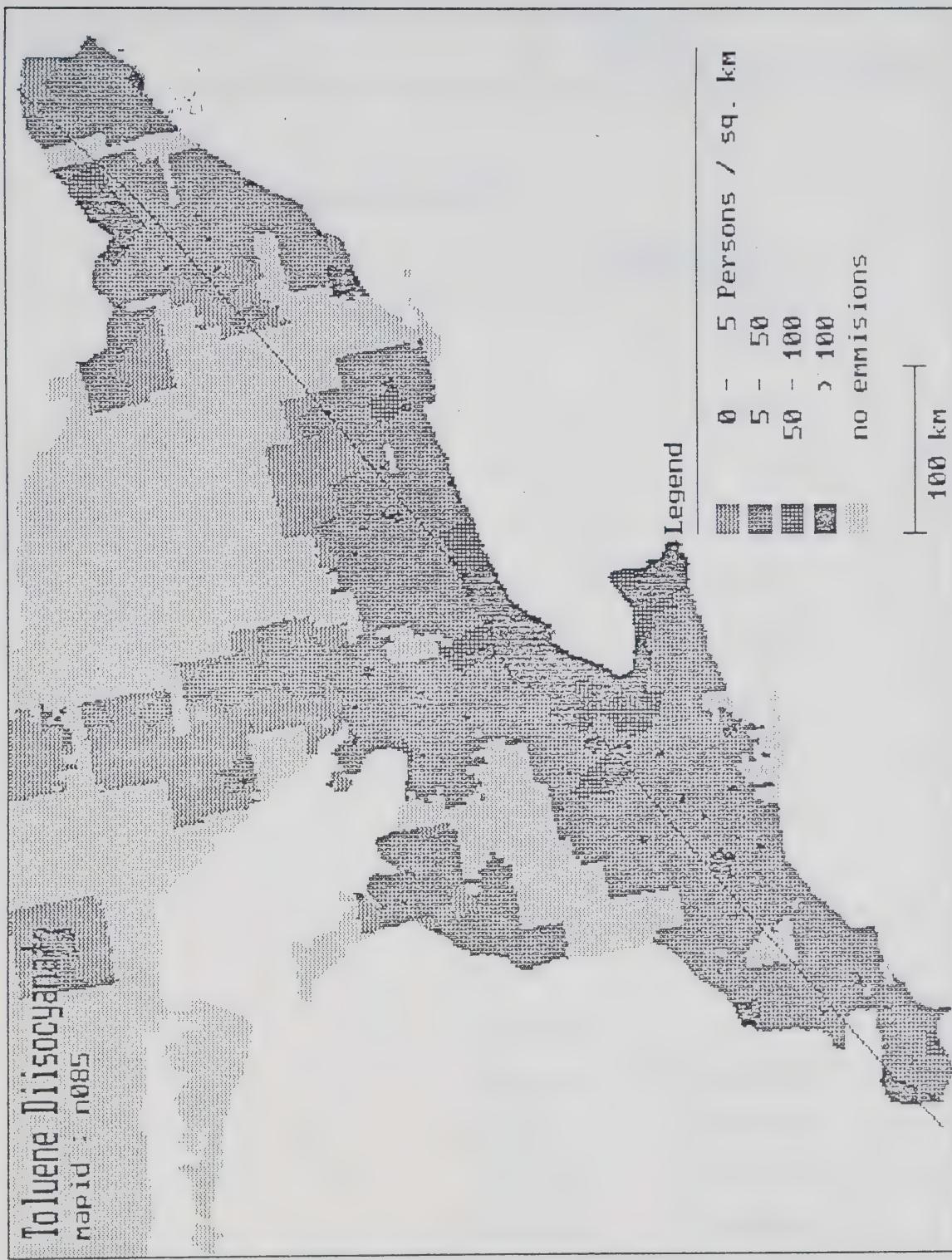
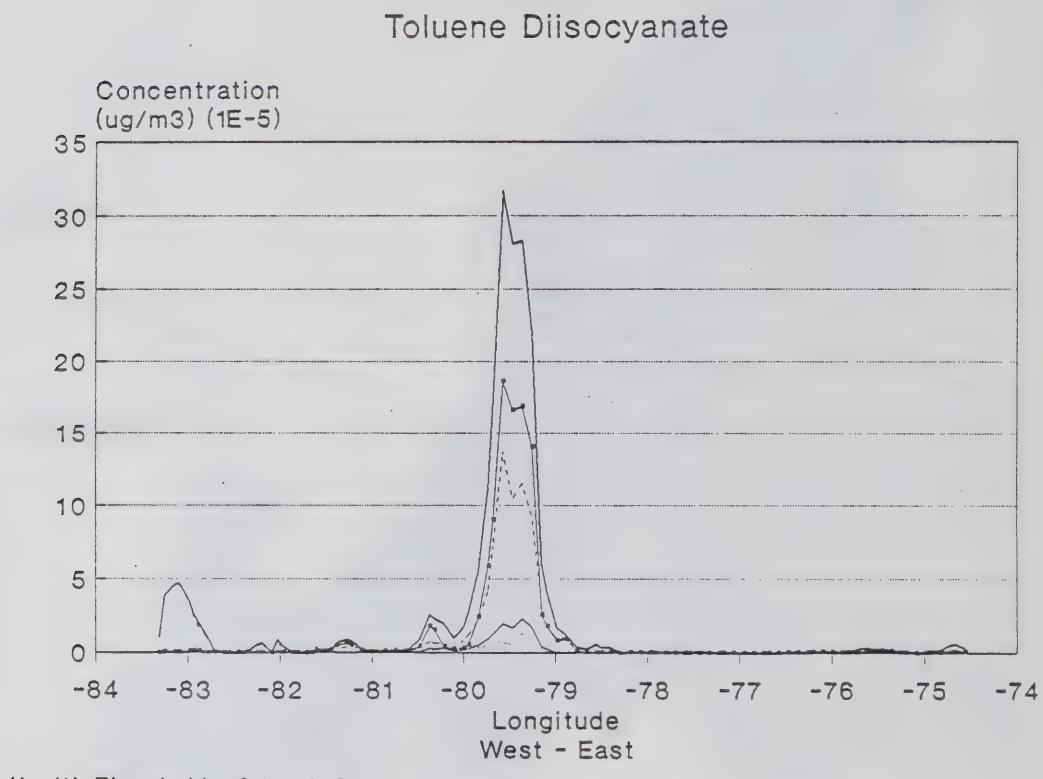


EXHIBIT I.98: PROFILE OF TOLUENE DIISOCYANATE CONCENTRATION DUE TO REGULATION 308 SOURCE EMISSIONS ACROSS SOUTHERN ONTARIO



Legend

- | | |
|-----------------|-------------|
| Existing | — |
| Scenarios A & D | - - - |
| Scenario B | - - - - |
| Scenario C | - - - - - |
| Scenario E | - - - - - - |

EXHIBIT I.99: AREAS EXPOSED TO 1,1,1-TRICHLOROETHANE FROM REGULATION 308 SOURCE EMISSIONS

H - 99

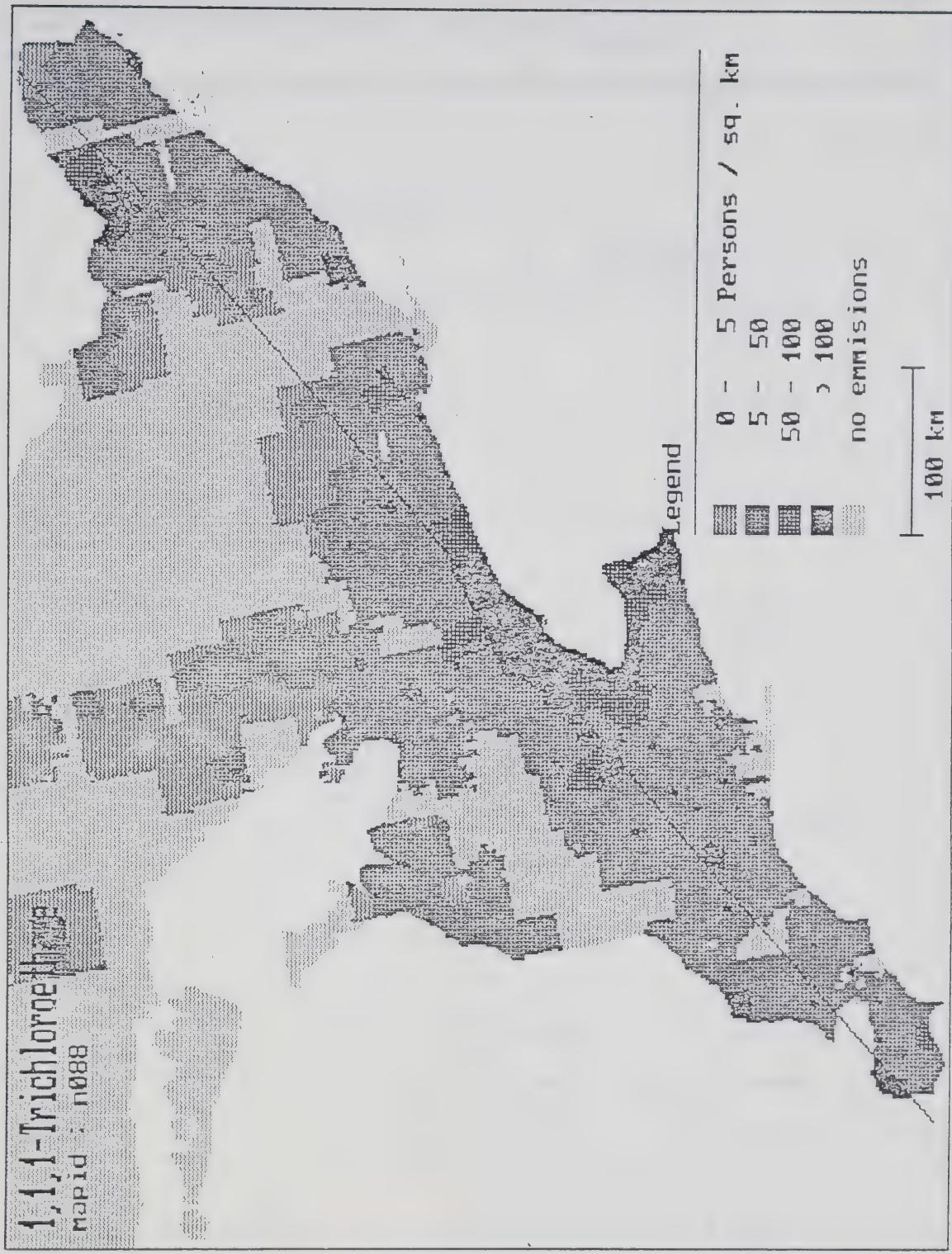
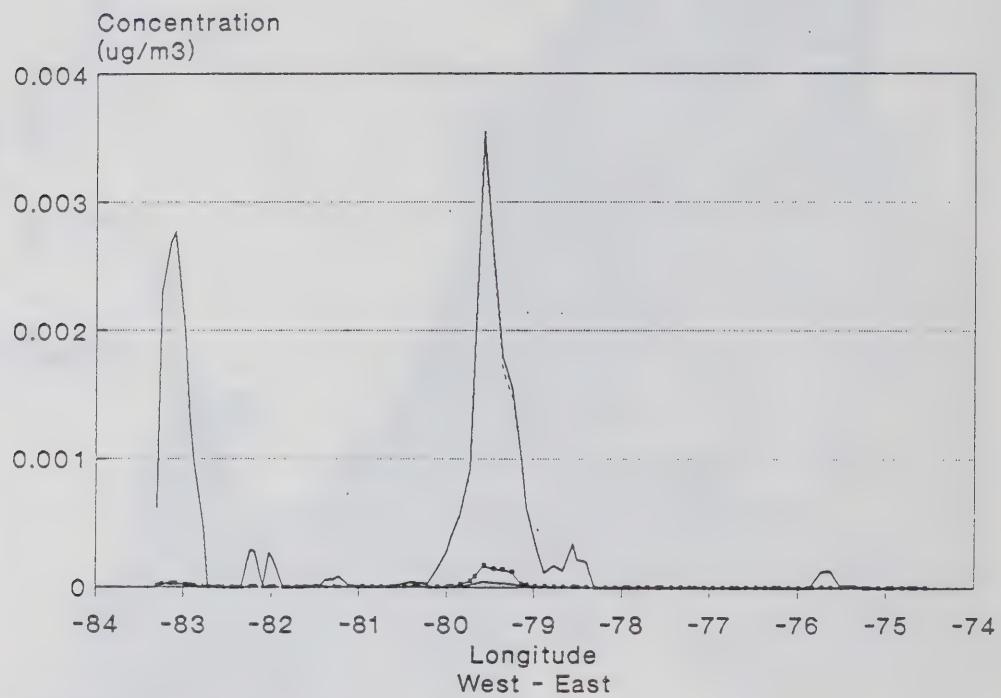


EXHIBIT I.100: PROFILE OF 1,1,1-TRICHLOROETHANE CONCENTRATION DUE TO REGULATION 308 SOURCE EMISSIONS ACROSS SOUTHERN ONTARIO

1,1,1-Trichloroethane



Health Threshold = 23000 ug/m³

Legend

- | | |
|-----------------|-------|
| Existing | _____ |
| Scenarios A & D | _____ |
| Scenario B | _____ |
| Scenario C | ----- |
| Scenario E | ***** |

EXHIBIT I-101: AREAS EXPOSED TO TRICHLOROBENZENES FROM REGULATION 308 SOURCE EMISSIONS

I - 101

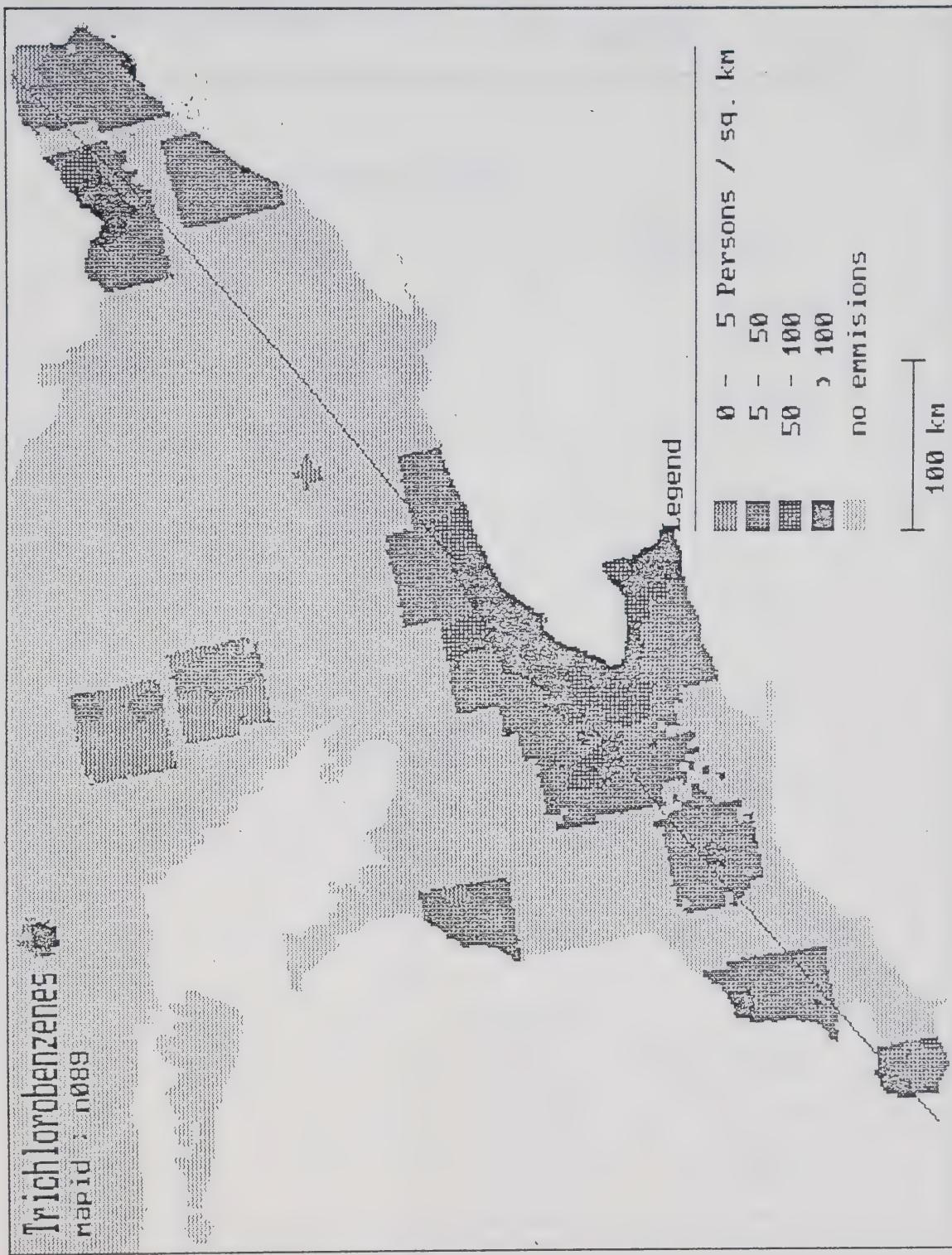
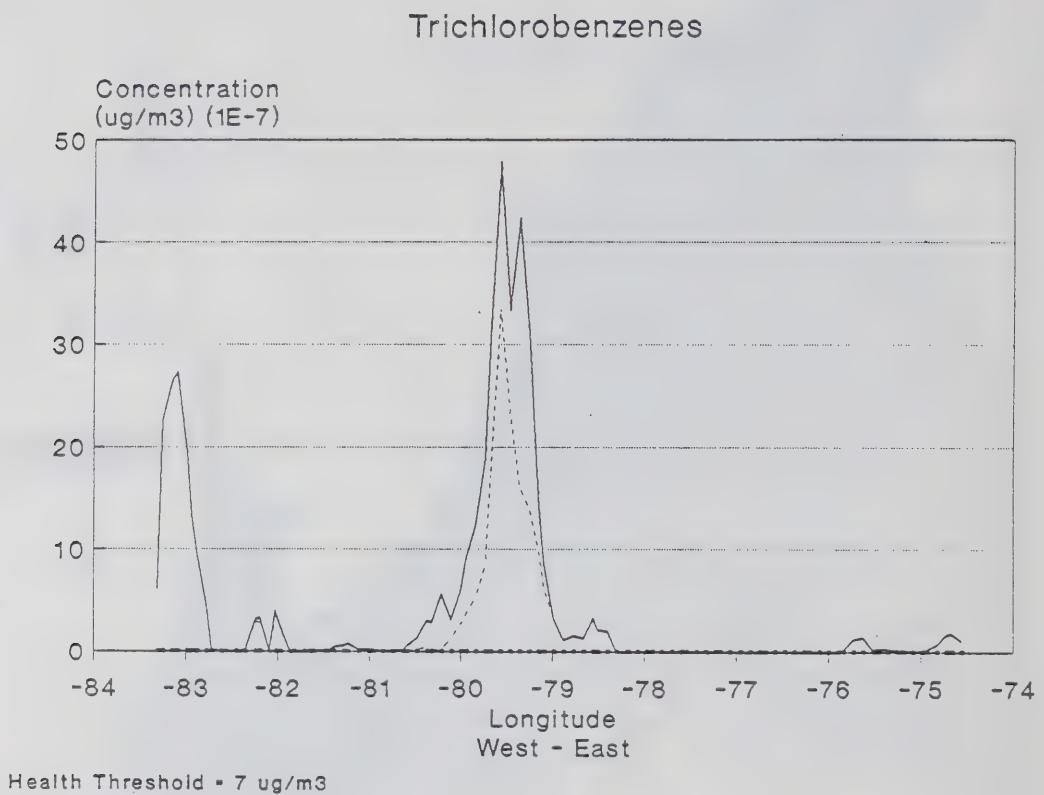


EXHIBIT I.102: PROFILE OF TRICHLOROBENZENES CONCENTRATION DUE TO
REGULATION 308 SOURCE EMISSIONS ACROSS SOUTHERN
ONTARIO



Legend

Existing	—
Scenarios A & D	- - -
Scenario B	— — —
Scenario C	.....
Scenario E	· · · · ·

EXHIBIT I.103: AREAS EXPOSED TO TRICHLOROETHYLENE FROM REGULATION 308 SOURCE EMISSIONS

H - 103

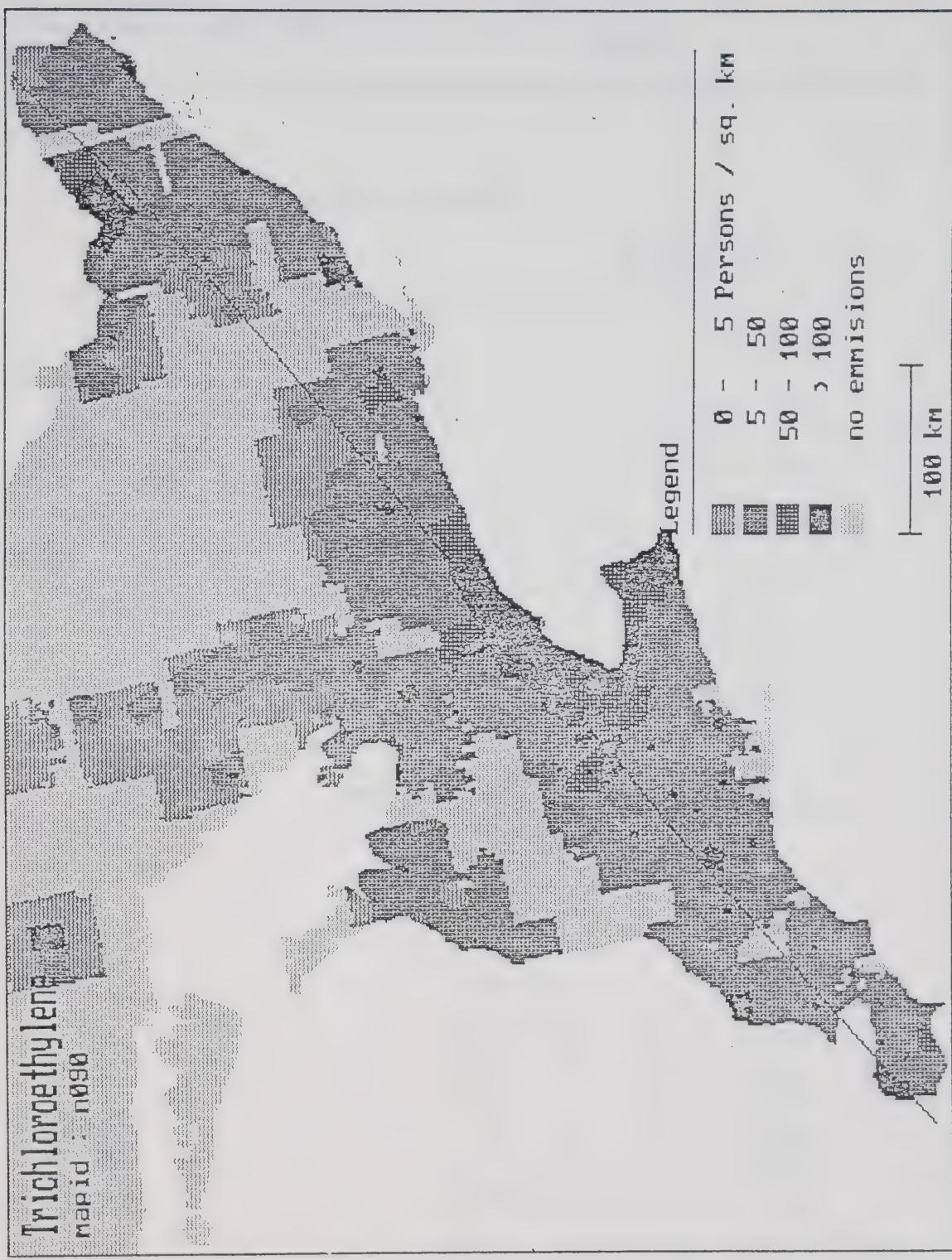
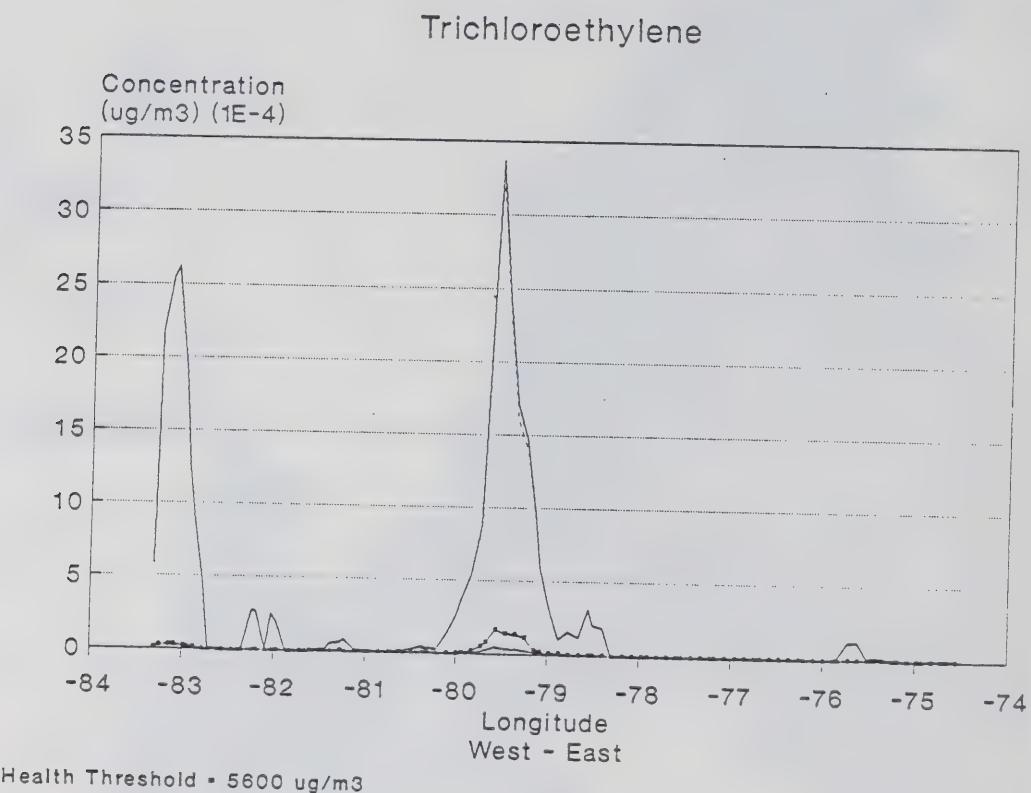


EXHIBIT I.104: PROFILE OF TRICHLOROETHYLENE CONCENTRATION DUE TO
REGULATION 308 SOURCE EMISSIONS ACROSS SOUTHERN
ONTARIO



Legend

- | | |
|-----------------|-------|
| Existing | _____ |
| Scenarios A & D | _____ |
| Scenario B | _____ |
| Scenario C | ----- |
| Scenario E | ..... |

EXHIBIT I.105: AREAS EXPOSED TO VINYL CHLORIDE FROM REGULATION 308 SOURCE EMISSIONS

I - 105

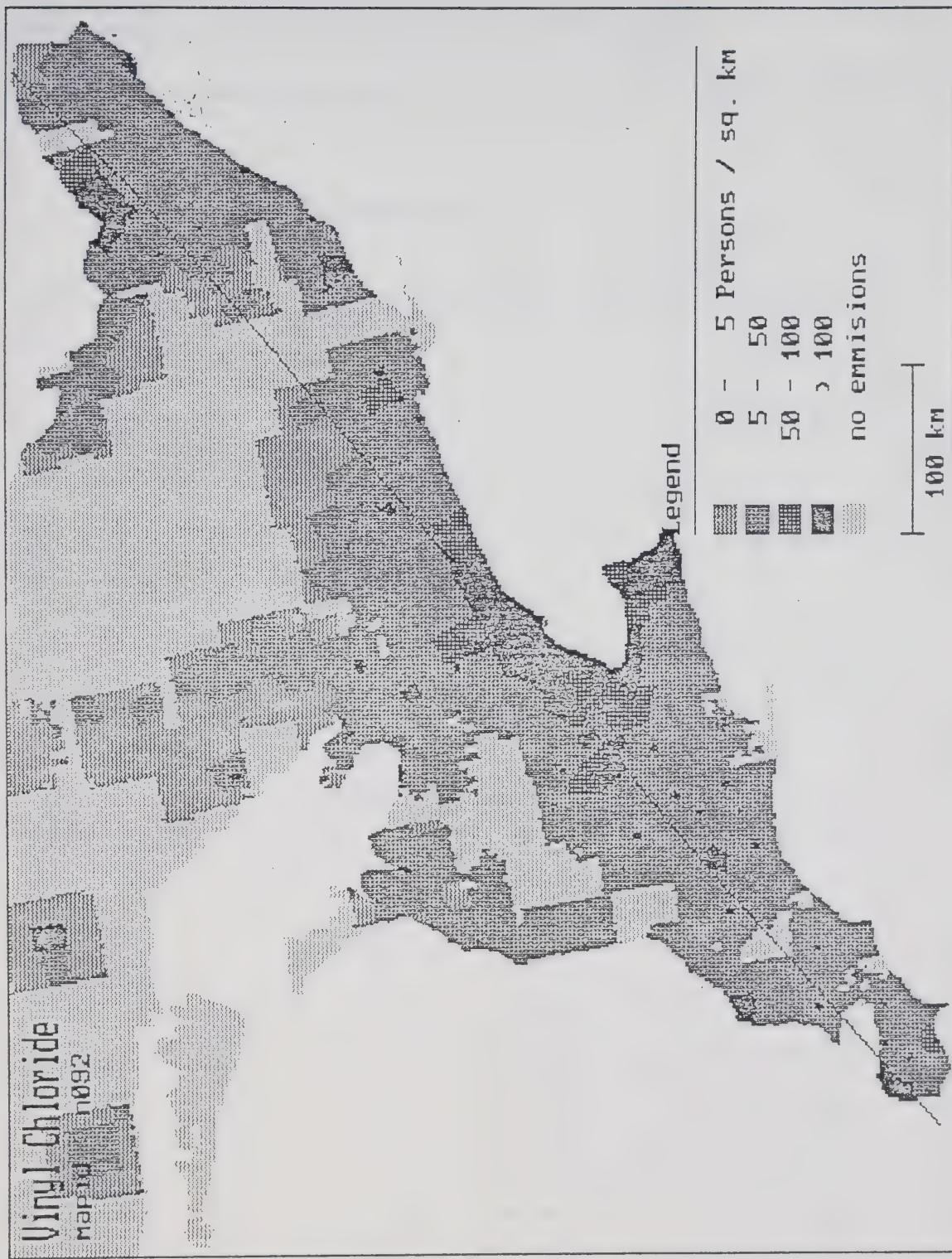
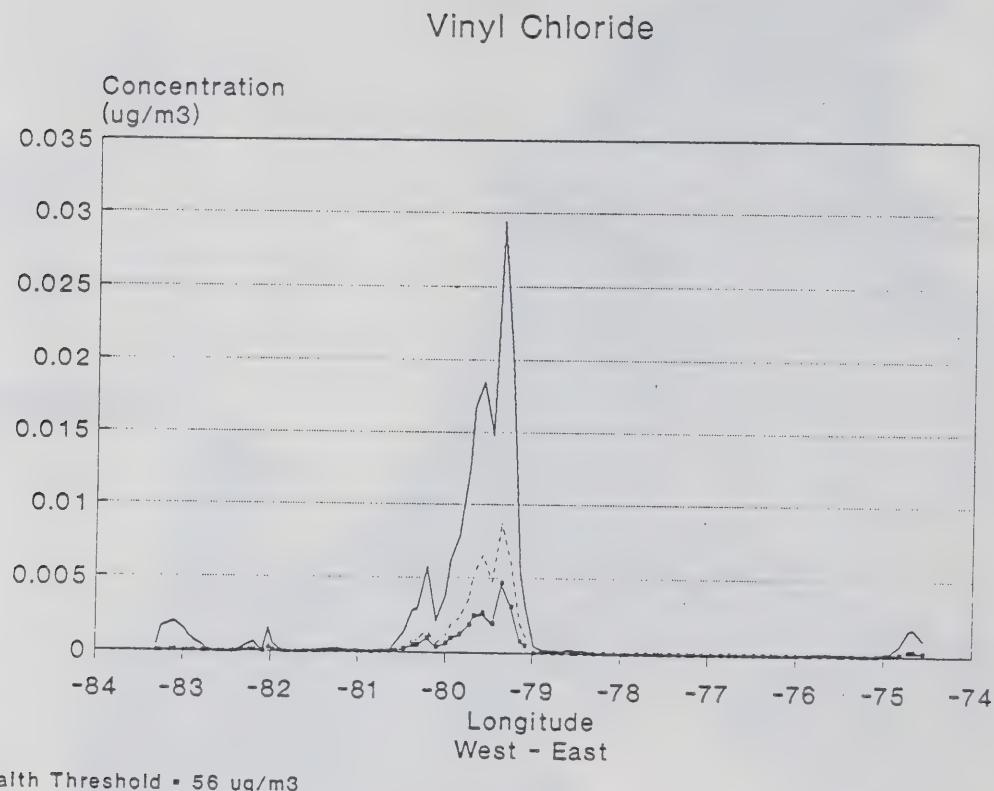


EXHIBIT I.106: PROFILE OF VINYL CHLORIDE CONCENTRATION DUE TO
REGULATION 308 SOURCE EMISSIONS ACROSS SOUTHERN
ONTARIO



Legend

- | | |
|-----------------|-------|
| Existing | — |
| Scenarios A & D | — |
| Scenario B | — |
| Scenario C | ..... |
| Scenario E | ..... |

EXHIBIT I.107: AREAS EXPOSED TO XYLENES FROM REGULATION 308 SOURCE EMISSIONS

I - 107

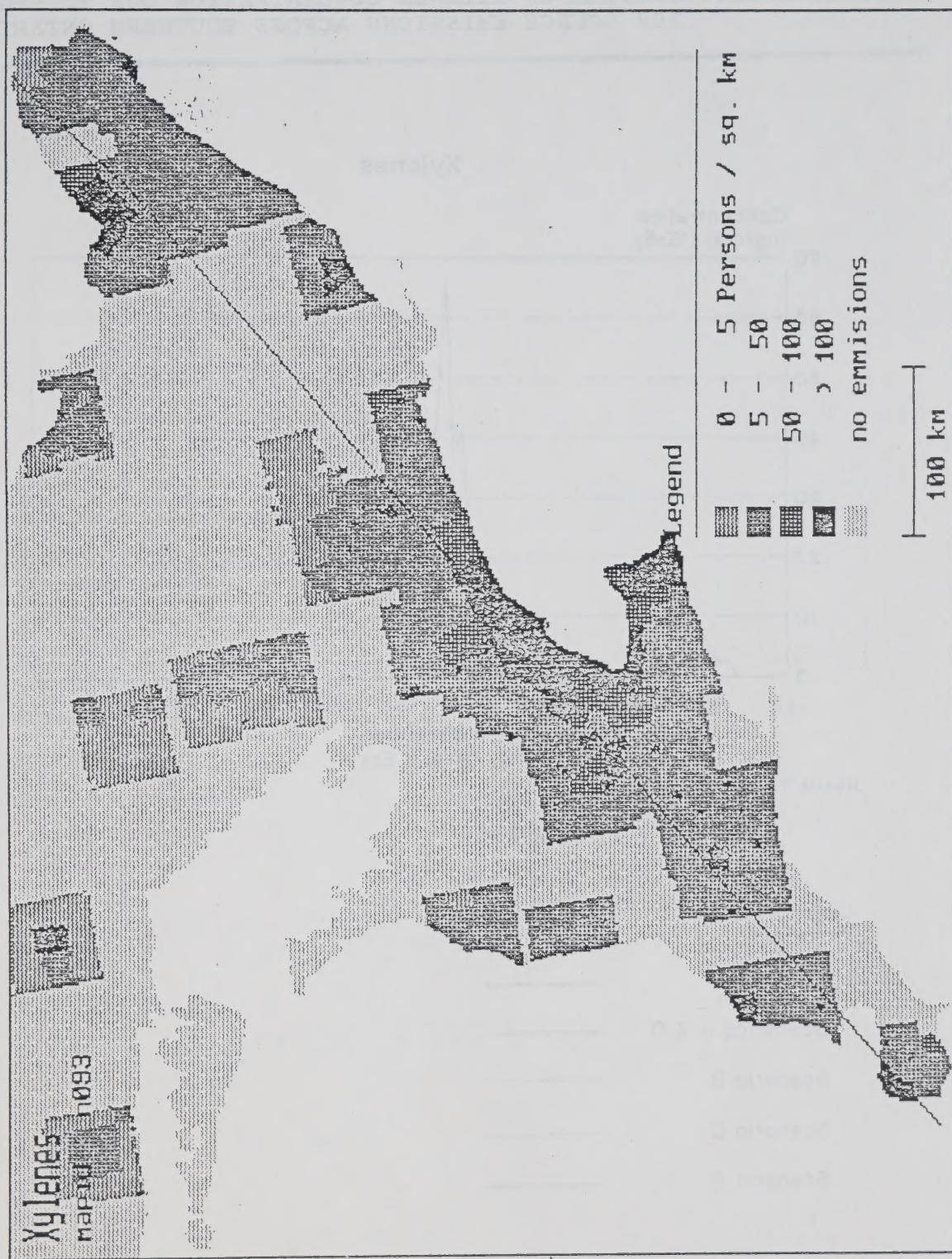
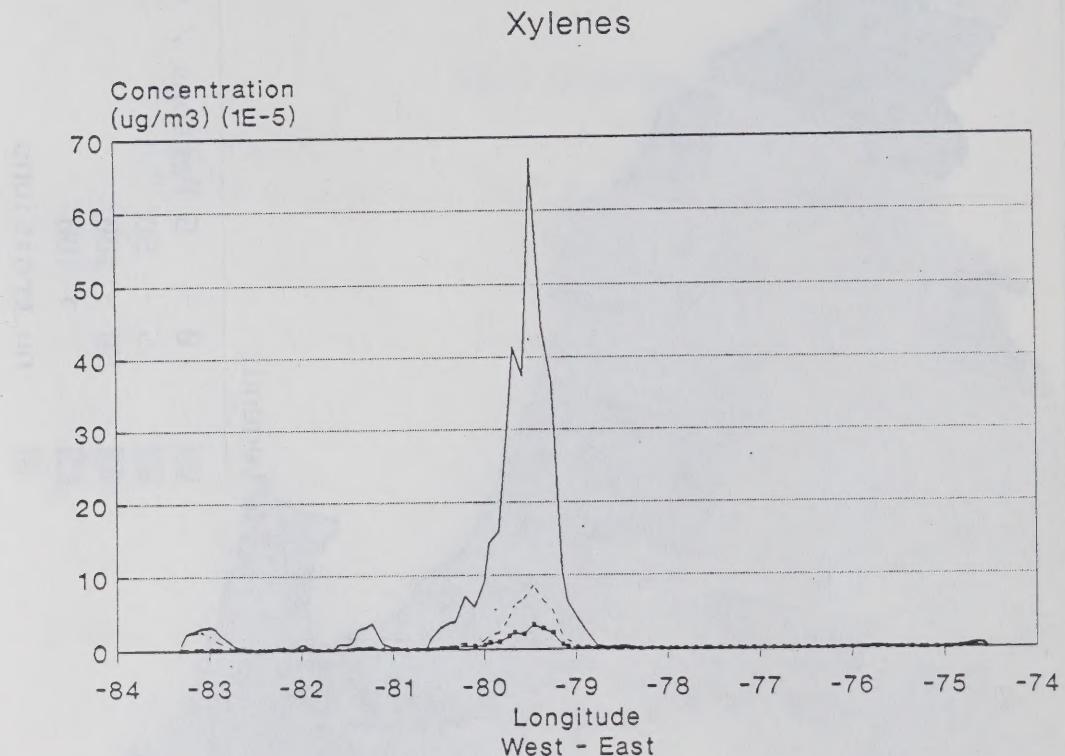


EXHIBIT I.108: PROFILE OF XYLEMES CONCENTRATION DUE TO REGULATION
308 SOURCE EMISSIONS ACROSS SOUTHERN ONTARIO



Legend

Existing	—
Scenarios A & D	—
Scenario B	—
Scenario C	-----
Scenario E	.....

